



Non-destructive survey method of soil air, survey apparatus, non-destructive cleanup method of contaminated soil and pressure bulkhead used therein

Technical Field

The present invention relates to a non-destructive survey method of soil air, a survey apparatus, a non-destructive cleanup method of contaminated soil and a pressure bulkhead used therein, and more particularly to a survey method not involving the destruction of the in-situ without proceeding to a boring operation in the soil horizons targeted as the subject of surveyed or cleaned up.

Background Art

The geological contamination of the soil or the groundwater by volatile organic compounds (hereinafter referred to as "VOCs") such as trichloroethylene and tetrachloroethylene has become a social issue and it has become an urgent task to take measures for cleaning them up.

Up to now as a survey technology for soil contamination, the survey of soil air method consisting of sampling soil air by inserting soil air sampling tubes or gas probes into a drilled hole or holes or the gas survey method consisting of directly sucking the air are known. However, these prior arts have the following disadvantages.

(1) The method of sucking soil air by means of a drilled hole or holes requires a drilling operation at the in-situ. For this reason, this method requires a long period of time from the start of the operation until the end of the survey. And this is a very uneconomical method because the boring operation is costly. In addition, this method, being a destructive test at the in-situ, imposes a high burden on the environment.

And the process of drilling a sampling hole by means of a simplified driver presents similar disadvantages although there may be differences in the extent.

(2) The method of sucking soil air by means of a drilled hole requires the extraction of a drill rod after the hole is drilled to a required depth. For this reason, at the time of extracting the drill rod, the flow of air into the hole disrupts soil air and prevents any suitable surveys from being made.

(3) The method of sucking soil air by using a drilled hole consists of sampling soil air containing volatile gases from a hole of horizontally a small surface of approximately $\phi 100\text{mm}$ in diameter. And a sampling hole made by a simplified driver has a very small sampling surface of approximately $\phi 10\text{mm}$ in diameter. For this reason, a



sampling hole represents a punctual area for evaluation, and for determining the source of soil contamination in a vast plant site, a large number of drilling points for survey will be required.

(4) The gas survey method of directly sucking the air is affected by the flow of wind and therefore cannot determine the source of contamination.

And the following technologies have generally been known in the past for cleaning up contaminated soil.

(1) The method of creating a negative pressure environment under the ground level to volatilize VOCs.

(2) The method of pumping up contaminated groundwater from a well for drawing water, cleaning up the contaminated groundwater by a cleanup apparatus on the ground and returning the purified water underground through a return well.

(3) The method of inserting or injecting a heating material or a heating chemical underground, heating VOCs and promoting their volatilization.

(4) The method of excavating contaminated soil and other related matters by means of a hydraulic excavator and cleaning up the contaminated soil by a cleanup machine on the ground.

(5) The method of injecting bacteria or a chemical product designed to promote the activities of bacteria underground through a drilled hole and taking advantage of the dissolution function of contaminants by the bacteria.

However, said prior arts require the creation of a drilled hole or a well or the use of a hydraulic excavator to excavate, and any of the prior arts destroys the in-situ even though they are intended for cleaning up. Accordingly, it is impossible to reproduce the in-situ after the cleanup as it had been before contamination. And the execution of a boring operation or the operation of large machines inevitably add up the cost of cleanup.

And in case of a narrow site of contamination, the difficulty of installing large machines often prevents the creation of a well for drawing water at the optimum position for cleanup. And in the case of the contamination of groundwater, the area of contamination is often extended, and the execution of drilling operation is often restricted due to the residential area or roads, and appropriate measures of cleanup are often prevented. And when it is found that the position of the well is not adequate after the cleanup work has started, it is difficult and costly to change the position of the well.

The present invention was made based on the technological background mentioned above and is designed to achieve the following objects.

It is the object of the present invention to provide a non-destructive survey method

of soil air capable of avoiding boring and other costly processes involving the destruction of the in-situ and enabling to carry out surveys of soil contamination at any optional place at a low cost, easily and without fail and an apparatus thereof.

Another object of the present invention is to provide a non-destructive method of cleaning up contaminated soil capable of cleaning up the same without destroying the site of cleanup and not subject to any restrictions due to the environment at the site of work, whereby the cleanup facilities can be easily installed, transferred and withdrawn and the cost of work can be reduced to a low level and a pressure bulkhead used therein.

Disclosure of the Invention

The present invention designed to achieve said objects relates to a non-destructive survey method of soil air comprising the steps of disposing a pressure bulkhead having an opening in such way that said opening may face the ground surface, maintaining the inside space of said pressure bulkhead at a negative pressure and sampling soil air in said pressure bulkhead for a survey,

wherein said pressure bulkhead is of at least a double construction comprising an outside pressure bulkhead and an inside pressure bulkhead, the soil air that flowed into the outside space between said outside pressure bulkhead and the inside pressure bulkhead is discharged outside and at the same time the soil air that flowed into the inside space within the inside pressure bulkhead is sampled for survey.

And the present invention relates to a survey apparatus of soil air wherein a pressure bulkhead having an opening is disposed in such a way that said opening may face the ground surface, the inside space of said pressure bulkhead maintained at a negative pressure and the soil air is sampled within said pressure bulkhead for a survey,

wherein said pressure bulkhead is at least of a double construction comprising an outside pressure bulkhead and an inside pressure bulkhead, and

a suction means for maintaining the outside space between said outside pressure bulkhead and the inside pressure bulkhead and the inside space within said inside pressure bulkhead at a negative pressure and for discharging the soil air that flowed in said outside space outside, and

a means for sampling the soil air that flowed in said inside space.

Said suction means is linked with a suction hole created in said outside pressure bulkhead and a link hole linking said outside space with said inside space is formed on said inside pressure bulkhead. A air tightness maintaining member is provided to block

the inflow of the air into the outside space on the opening of said outside pressure bulkhead. Said air tightness maintaining member is an annular flexible body fitted into said opening of said outside pressure bulkhead. Said air tightness maintaining member is a cylindrical body to be buried underground. Said sampling means of soil air comprises sampling holes respectively created in said outside pressure bulkhead and inside pressure bulkhead and a sampling tube inserted into said inside space through these sampling holes for sucking and sampling soil air.

In addition, in order to achieve said objects, the present invention relates to a non-destructive cleaning up method of contaminated soil comprising the steps of forming zones of hermetic space on the surface of the soil horizon targeted as the subject of survey, and

sucking air contained in said hermetic space by the suction apparatus, keeping said hermetic space at a negative pressure and sucking into said hermetic space contaminants such as VOCs contained in said soil horizon, and

sucking and discharging outside the sucked contaminants by means of said suction apparatus.

Said hermetic space may be formed by disposing the pressure bulkhead having an opening in such a way that said opening may face the ground surface. In this connection, a means for blocking the inflow of the air into said pressure bulkhead may be provided around said opening. In this case, a banking may be created around said opening or said opening may be buried underground as said means for blocking the inflow of the air.

The present invention also relates to a pressure bulkhead used for the cleanup of contaminated soil wherein an opening is created on the surface of the soil horizon targeted as the subject of survey in such a way that the opening may face the ground surface, and the inside space is set at a negative pressure so that VOCs and other contaminants contained in said soil air may be sucked therein, and

an air tightness maintaining member is provided to block the inflow of the air on the periphery of said opening.

Said air tightness maintaining member may be formed by a deformable annular flexible body conforming to the shape of the ground surface. Said air tightness maintaining member may also be formed by a flexible body in the form of a sheet expanding on the periphery of said opening. And said air tightness maintaining member may be formed by a hard cylindrical body buried in said soil horizon.

Brief Description of the Drawings

Fig. 1 is a longitudinal sectional view showing the mode of carrying out the survey method of soil air and the apparatus according to the present invention;

Fig. 2 is a longitudinal sectional view showing the sampling operation of soil air;

Fig. 3 is a diagram showing the process of sampling soil air and the pressure condition within the pressure bulkhead;

Fig. 4 is a longitudinal sectional view showing the mode of carrying out the cleanup method according to the present invention;

Fig. 5 is a longitudinal sectional view showing another mode of carrying out the cleanup method;

Fig. 6 is a longitudinal sectional view showing still another mode of carrying out the cleanup method;

Fig. 7 is a longitudinal sectional view showing a preferred mode of carrying out the pressure bulkhead;

Fig. 8 is a longitudinal sectional view showing another mode of carrying out the pressure bulkhead; and

Fig. 9 is a longitudinal sectional view showing still another mode of carrying out the pressure bulkhead.

The Best Mode of Carrying out the Invention

The mode of carrying out the present invention shall be described below by referring to drawings. Fig. 1 shows a non-destructive survey apparatus of soil air according to the present invention, wherein the pressure bulkhead 1 is of a double construction comprising an outside pressure bulkhead 2 and an inside pressure bulkhead 3 disposed inside thereof. The outside pressure bulkhead 2 and the inside pressure bulkhead 3 have respectively openings 4 and 5. The outside pressure bulkhead 2 and the inside pressure bulkhead 3 are disposed on the ground surface G in such a way that the openings 4 and 5 may face the ground surface G. Accordingly, an outside space 7 between the outside pressure bulkhead 2 and the inside pressure bulkhead 3 and an inside space 8 inside the inside pressure bulkhead 3 are respectively hermetically formed on the ground surface G.

The opening 4 of the outside pressure bulkhead 2 is fitted with an air tightness maintaining member 9 to block the inflow of air into the outside space 7. This air tightness maintaining member 9 is an annular flexible body fitted on the circumference of the opening 4. This annular flexible body is made of rubber or a high molecular material that displays its sealing function by adhering closely to the uneven structure of the ground surface G. It is desirable that the opening 5 of the inside pressure

bulkhead 3 would be fitted with a similar air tightness maintaining member 10.

And for the air tightness maintaining member, a tubular body not shown may be fitted into the openings 4 and 5 in place of an annular flexible body. And it is possible to have its sealing function demonstrated by driving and burying this tubular body to a suitable depth in the ground.

A suction hole 11 is created on the outside pressure bulkhead 2 and this suction hole 11 is linked with a suction means 13 such as a vacuum pump through a suction pipe 12. A pressure gauge 14 is mounted on the suction pipe 12. The suction means 13 is controlled by a controller 15 to which the measurement signals of the pressure gauge 14 is inputted, and is designed as shown in Fig. 3 in such a way that the pressure (negative pressure) within the pressure bulkhead 1 and the time of maintaining such pressure can be set optionally.

A sampling hole 16 is created also on the outside pressure bulkhead 2 and a sampling pipe for soil air described below is inserted therein. This sampling hole 16 is hermetically closed by a plug 17 when soil air is sucked. A link hole 18 linking the outside space 7 and the inside space 8 is created on the inside pressure bulkhead 3. This link hole 18 concurrently serves as a sampling hole of soil air.

As the inside space of the outside pressure bulkhead 2 and the inside pressure bulkhead 3 is maintained at a negative pressure, in other words at a pressure lower than the atmospheric pressure, they be most preferably formed in a thin and light roughly hemispheric shape which is quite strong against buckling. However, it is possible to form them into a cylindrical shape or a square or polygonal cylindrical shape.

Then, the method of sampling soil air at the in-situ by using said survey apparatus of soil air will be described below by referring to Figs. 1 – 3.

The outside pressure bulkhead 2 and the inside pressure bulkhead 3 are disposed on the ground surface G at the in-situ in such a way that the openings 4 and 5 may face the ground surface G. When a pressure reducing means 13 is operated in this state, air contained in the outside space 7 and the inside space 8 linked each other through the linkage hole 18 is sucked, and the pressure within the pressure bulkhead 1 changes to a negative one. As a result, the outside space 7 and the inside space 8 are respectively filled with soil air 20 and 21.

At this time, in spite of the presence of the air tightness maintaining member 9, the inflow of air 23 from the opening 4 of the outside pressure bulkhead 2 into the outside space 7 is unavoidable, and the distribution of pressure (distribution of negative pressure) within the pressure bulkhead 1 will be as shown by the code

number 22. In other words, the soil air 20 that flowed into the outside space 7 will be mixed by air that flowed in 23, and such mixed air reduces the precision of measurement. Accordingly, it will be discharged outside by the suction means 13 from the suction hole 11.

On the other hand, only soil air 21 with which air that flowed in 23 does not mix flows into the inside space 8. Therefore, the size of the inside pressure bulkhead 3 is designed to be sufficiently smaller than that of the outside pressure bulkhead 2. The size of the inside pressure bulkhead 3 is set by taking into account the expanse of the ground surface targeted as the subject of survey of contaminated soil, transportation and manageability at the in-situ. Although it depends on the scale of the suction means 13, for example a diameter of $\phi 300\text{mm}$ or more can be easily realized.

And after a specified length of time has passed, as shown in Fig. 2, a gas sampling pipe 24 is inserted into the sampling holes 16 and 18 to suck and sample the soil air 21 that has gathered in the inside space 8. For the gas sampling pipe 24, a well-known gas detecting pipe having a gas suction hole at the top may be used.

As described in details above, the following unprecedented outstanding effects can be obtained according to the present invention.

(1) Costly boring process involving destruction at the in-situ can be omitted in comparison with the conventional method of sucking soil air by means of drilled holes. Accordingly, it is possible to make sure that contaminated soil would be surveyed at a low cost, easily and in a short length of time.

(2) Since no atmospheric air flows into the inside space, and soil air not mixed or disrupted by the inflow of the air can be sampled, it is possible to make sure that contaminated soil would be surveyed.

(3) The inside pressure bulkhead with a diameter of $\phi 300\text{mm}$ or more can be easily realized, and a sampling area of 900 – 9 times or more larger than the conventional drilled holes with a diameter of approximately $\phi 10 - 100 \text{ mm}$ can be realized. Therefore, for specifying the source of soil contamination in a vast plant site by “area evaluation,” it is possible to drastically reduce the number of survey points in comparison with the conventional survey methods and therefore this method is very efficient.

(4) In comparison with the gas survey method of directly sucking the air, this method is not affected by the movement of wind and other factors, and therefore it is possible to ensure that contaminated soil would be surveyed.

And now, the mode of carrying out the non-destructive cleanup method of contaminated soil according to the present invention will be described below. Fig. 4 is a

sectional view showing the mode of carrying out the same. The soil horizon 31 shown in Fig. 4 is contaminated by VOCs (shown by code number 32), and this soil horizon 31 is targeted as the subject of a cleanup operation and the following treatments shall be carried out.

The pressure bulkhead 33 in this mode of carrying out is a cylindrical or a square or polygonal cylindrical member and has an opening 34. Inside this pressure bulkhead 33, a suction pipe 38 linked with a suction apparatus 37 such as a vacuum pump opens its mouth. Incidentally, the pressure bulkhead 33 is made of stainless steel or other pressure tight materials and can be made of any pressure tight materials of whatever nature or type. For example, it can be made of a plastic board with a reinforcing member on the inside or outside circumference. And its shape is not limited to a cylinder, and a hemisphere or other various shapes can be adopted.

This pressure bulkhead 33 is disposed on the ground surface G of the soil horizon 31 targeted as the subject of cleanup operation in such a way that the opening 34 may face the ground surface G. As a result, a hermetically closed space 36 is zoned on the ground surface G. And the suction apparatus 37 is operated to suck the air contained in the pressure bulkhead 33 and change the pressure inside to a pressure lower than the atmospheric pressure (negative pressure). This will promote the movement of fluids such as soil air contained in the soil horizon 31, and the soil fluid is absorbed into the pressure bulkhead 33 as shown by the arrow in Fig. 4. As a result of this suction of soil fluid, VOCs 32 contained therein flow into the pressure bulkhead 33, and VOCs that existed then as a liquid volatilizes, and then pass through the suction pipe 38 to be discharged outside.

The concentration of VOCs discharged from the suction apparatus 37 may be measured and monitored by a concentration measuring instrument not shown to manage the progress of any cleanup treatment. Or an adsorption apparatus in which activated charcoal is used may be linked with a suction apparatus 37 through a piping to adsorb VOCs. Incidentally, said mode of carrying out is based on the assumption that the existence of VOCs is confirmed in a prior survey. However, it is possible to conduct a survey according to a method similar to the one mentioned above, in other words to confirm the existence of VOCs by means of a concentration measuring instrument, and then to proceed to a cleanup operation.

When the air tightness between the top surface of the opening 34 in the pressure bulkhead 33 and the ground surface 35 is insufficient, air flows into the pressure bulkhead 33 and prevents an efficient suction of fluids such as soil air. Figs. 5 and 6 show the modes of carrying out wherein measures are taken to block the inflow of air

into the pressure bulkhead 33. In other words, Fig. 5 shows a mode of carrying out wherein a banking 40 is created around the opening 34 of the pressure bulkhead 33 as a means of blocking the inflow of air. And the mode of carrying out shown in Fig. 6 represents the opening 34 buried underground as a means of blocking the inflow of air.

The mode of carrying out of said cleanup method does not provide any member for maintaining air tightness in the pressure bulkhead itself. It is possible to provide an air tightness maintaining member in the pressure bulkhead itself to block the inflow of air. And now a preferred mode of carrying out thereof will be described below. Some preferred modes of carrying out the same will be described below.

The mode of carrying out shown in Fig. 7 represents a case in which an annular flexible body 41 is provided as an air tightness maintaining member at the top of the opening 34 in the pressure bulkhead 33. The annular flexible body 41 is a ring of the same shape as that of the opening 34, for example a circular ring or a polygonal ring, having a specified height and a specified thickness greater than the thickness of the pressure bulkhead 33 (dimension between the inner and outer diameter).

The annular flexible body 41 is made of for example a soft rubber material. And in the state wherein the pressure bulkhead 33 is disposed, it deforms conforming to the shape of the ground surface G, and the surface of contact with the ground surface G increases. Therefore, the air tightness between the top surface of the opening 34 and the ground surface G is maintained and the inflow of air is prevented. Thus, it will be possible to suck efficiently fluids such as soil air.

The mode of carrying out shown in Fig. 8 represents a case wherein a flexible body in the form of a sheet 42 is provided as an air tightness maintaining member at the top surface of the opening 34 in the pressure bulkhead 33. The flexible body in the form of a sheet 42 has an expansion 43 expanding on the outer circumference of the opening 34. The flexible body in the form of a sheet 42 is made of for example a soft rubber material just as the annular flexible body 41 shown in Fig. 7. And in the state where the pressure bulkhead 33 is disposed, it spreads in the form of a disk (when the external shape is circular) conforming to the ground surface G, and a sufficiently large area of contact with the ground surface G for the thickness of the pressure bulkhead 33 can be obtained.

And by placing and solidly fixing a banking or other loads 44 on the expansion 43, it is possible to make the expansion 43 adhere closely to the ground surface G and to maintain a sufficient air tightness. In the case of the mode of carrying out shown in Figs. 7 and 8, however, water or other fluids may be allowed to penetrate as a sealing material on the ground surface G that will be in contact with the annular flexible body

41 or the flexible body in the form of a sheet 42, which will increase the close adherence with the ground surface and further enhance the air tightness.

The mode of carrying out shown in Fig. 9 represents a case wherein a cylindrical body 45 is provided as an air tightness maintaining member at the top of the opening 34 in the pressure bulkhead 33. The cylindrical body 45 is made of steel and other hard materials, and it is thicker than the pressure bulkhead 33. By burying such a cylindrical body 45 underground, it is possible to ensure that air tightness will be maintained.

As described in details above, it is possible to obtain the following outstanding effects according to the present invention.

(1) As it is unnecessary to dig a well or excavate by using a hydraulic excavator, the soil condition at the in-situ is not destroyed.

(2) As neither boring work nor other works involving the use of large machines is required, the cost of cleanup operation can be drastically reduced.

(3) As no well for pumping up water is required, it will be possible to cope with narrow contamination sites. In addition, since no boring or any other operation is required for cleanup, there will be no restrictions for cleanup measures due to residential area or roads.

(4) Even when it has become evident that the position of a pressure bulkhead is not optimum after the cleanup operation had started, the position of the machine can be easily changed.

Claims

1. A non-destructive survey method of soil air comprising the steps of disposing a pressure bulkhead having an opening in such way that said opening may face the ground surface, maintaining the inside space of said pressure bulkhead at a negative pressure and sampling soil air in said pressure bulkhead for a survey,

wherein said pressure bulkhead is of at least a double construction comprising an outside pressure bulkhead and an inside pressure bulkhead, the soil air that flowed into the outside space between said outside pressure bulkhead and the inside pressure bulkhead is discharged outside and at the same time the soil air that flowed into the inside space within the inside pressure bulkhead is sampled for a survey.

2. A survey apparatus of soil air wherein a pressure bulkhead having an opening is disposed in such a way that said opening may face the ground surface, the inside space of said pressure bulkhead maintained at a negative pressure and the soil air is sampled within said pressure bulkhead for a survey,

wherein said pressure bulkhead is at least of a double construction comprising an outside pressure bulkhead and an inside pressure bulkhead, and

a suction means for maintaining the outside space between said outside pressure bulkhead and the inside pressure bulkhead and the inside space within said inside pressure bulkhead at a negative pressure and for discharging the soil air that flowed in said outside space outside, and

a means for sampling the soil air that flowed in said inside space.

3. The survey apparatus of soil air according to claim 2 wherein said suction means is linked with said outside pressure bulkhead and a link hole linking said outside space with said inside space is formed on said inside pressure bulkhead.

4. The survey apparatus of soil air according to claim 2 wherein an air tightness maintaining member is provided to block the inflow of air into the outside space on the opening of said outside pressure bulkhead.

5. The survey apparatus of soil air according to claim 4 wherein said air tightness maintaining member is an annular flexible body fitted into said opening of said outside pressure bulkhead.

6. The survey apparatus of soil air according to claim 4 wherein said air tightness maintaining member is a cylindrical body to be buried underground.

7. The survey apparatus of soil air according to claim 2 wherein said sampling means of soil air comprises sampling holes respectively created in said outside pressure bulkhead and inside pressure bulkhead and a sampling tube inserted into said inside

space through these sampling holes for sucking and sampling soil air.

8. A non-destructive cleanup method of soil air comprising the steps of zoning hermetic space on the ground surface of the soil horizon targeted as the subject of cleanup, and

sucking the air contained in said hermetic space by the suction apparatus, keeping said hermetic space at a negative pressure and sucking into said hermetic space contaminants such as VOCs contained in said soil horizon, and

sucking and discharging outside the sucked contaminants by means of said suction apparatus.

9. The non-destructive cleanup method of contaminated soil according to claim 8 wherein said hermetic space is formed by disposing the pressure bulkhead having an opening in such a way that said opening may face the ground surface.

10. The non destructive cleanup method of contaminated soil according to claim 9 wherein a means for blocking the inflow of the air into said pressure bulkhead is provided around said opening.

11. The non destructive cleanup method of contaminated soil according to claim 10 wherein a banking is created around said opening or said opening is buried underground as said means for blocking the inflow of the air.

12. A pressure bulkhead used for the cleanup of contaminated soil wherein an opening is created on the surface of the soil horizon targeted as the subject of cleanup in such a way that the opening may face the ground surface, and the inside space is set at a negative pressure so that VOCs and other contaminants contained in said soil horizon may be sucked therein, and

an air tightness maintaining member is provided to block the inflow of air into said opening.

13. The pressure bulkhead used for the cleanup of contaminated soil according to claim 12 wherein said air tightness maintaining member is formed by a deformable annular flexible body conforming to the shape of the ground surface.

14. The pressure bulkhead used for the cleanup of contaminated soil according to claim 12 wherein said air tightness maintaining member is formed by a flexible body in the form of a sheet expanding on the periphery of said opening.

15. The pressure bulkhead used for the cleanup of contaminated soil according to claim 12 wherein said air tightness maintaining member is formed by a hard cylindrical body buried in said soil horizon.