DEVICE FOR THE COLLECTION OF UNDERSEA FRESHWATER RESURGENCES

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ABSTRACT
Device for the collection of undersea freshwater resurgences enabling freshwater to be recovered from springs flowing below sea level and derived in particular from karst networks, characterized by a hermetic wall that isolates the resurgences 2, which hermetic wall is anchored to the sea bottom 5 and reaching up to the surface 3 so that the upper part of the installation is always out of the water with valves.
DEVICE FOR THE COLLECTION OF UNDERSEA FRESHWATER RESURGENCES

[0001] This invention relates to a device for the collection of undersea freshwater resurgences.

[0002] Its aim is to enable freshwater to be recovered from springs that are located under sea level and derive in particular from karst networks.

[0003] The karst is a domain of calcareous rocks comprising many inter-communicating cavities, created by the calcium carbonate being dissolved by carbonic acid derived from rainwater loaded with CO₂, and according to a complex process involving bacterial action in particular. All these cavities make up a karst network, the lower part of which constitutes significant reservoirs of freshwater.

[0004] For reasons connected to geological evolution, the karsts, especially those of the Mediterranean rim, have often been lowered by several tens of meters, or even hundreds of meters in places, and as a result their base level can actually be located well below sea level.

[0005] It has been known for a long time that freshwater springs coming from karst domains flow under the sea, and in particular, but not solely, in the Mediterranean. However, the freshwater and seawater, which are liquids with different densities, do not mix while the flow of the two liquids remains laminar and not turbulent.

[0006] Attempts have been made to collect the freshwater from undersea karstic resurgences, based on the principle of a barrier stopping the flow of freshwater, with seawater ponding towards the bottom. This is, for example, what has been carried out at Port Micou near Marseilles, in Argolid (Greece) and also in Libya.

[0007] These operations often took place by forcing or restricting the natural hydraulics. However, a karst system is complex and open, with a random distribution of channels and cavities. Any attempt that modifies the natural equilibrium modifies the physical parameters and can result in increased intrusion of seawater into the system.

[0008] French patent FR 2 701 974 describes a submerged construction, comprising a concave part aimed downwards and covering the spring, the freshwater remaining trapped in the upper part of said cavity thanks to its density, which is less than that of the seawater. The lower part of this construction remains open so as to let the overflow, and in particular the seawater, escape, at the same time leaving the karst system unrestricted and removing the freshwater from the construction by means of a variable-flow pumping system. The pumping device is subordinate to sensors, which enable a flow rate slightly less than the spring’s flow rate to be maintained.

[0009] This device allows freshwater to be removed without the existing equilibrium being disturbed and without introducing disruptions into the working of the karst system, facilitating the laminar flow, which obviates the mixing with seawater.

[0010] In each case where undersea resurgences are collected, it is necessary to maintain the equilibrium between the two liquids, which is expressed by the formula

$$Hd/Hi = Ds/Dd$$

where \(Hd\) is the height of the column of freshwater, \(Hi\) the height of the column of seawater, \(Ds\) the density of the seawater and \(Dd\) the density of the freshwater.

[0011] These four parameters, which are stable to begin with, do not remain stable after the process separating the two waters starts and until a new equilibrium is established (after collection), which will remain unstable in every case, varying according to the flow rate of the karst network upstream.

[0012] As a result, in the case of collection via a closed system installed under sea level, controlling this equilibrium can often be tricky and, among other aspects, introduces an additional cost for the device.

[0013] French patent FR 2 785 001, application number 98 13349, describes a device having for subject an improvement that enables a significant simplification of the collection system and an equally significant reduction in the development cost. This device comprises an impermeable surface, for preference flexible, which isolates the resurgences, anchored to the sea bottom and reaching the surface where it is held by a floating barrier, thus enabling the ventilation of the collection device in all situations. The device also comprises a system of valves in the lower part of the membrane, thus allowing the seawater to escape; the freshwater is removed by pumps installed on a floating device (raft) on the surface.

[0014] Nevertheless, the results of the device conforming to French patent no FR 2 785 001 are, to a degree, random; new data and measurements (such as, for example, at the Anavilos installations in Greece) have highlighted these problems. The object of this invention is to respond to the problems concerning the operation and return of the devices in question and their application procedure. In particular, installations of this type (flexible barriers) must be equipped with a system controlling the flow rate from the springs in real time.

[0015] Such a system can be comprised of one or more currentmeters installed at the outlet of the karst channels and directly transmitting the speed of the output current directly to the control center. Knowing the diameter of the channel, the flow rate can be immediately derived from this.

[0016] The internal volume (capacity) of the basin delimited by the barrier must necessarily obey the formula

$$V = Qh/2 \text{ or } V > Qh/2$$

where \(V\)=total volume of the basin and \(Qh\)=the average hourly flow rate of the springs.

[0017] The barrier (circular or semicircular basin) must be equipped with an automatic control and alarm system able to activate the opening and disabling of the system when the cumulative snapshot flow rate of the springs intercepted by said barrier exceeds a certain value determined for each installation after studying the conditions relating to it. In fact, in an active karst system, there can be a hundredfold variation in the flow rate between low flow and exceptional flood rate.

[0018] The appended diagrams are given as examples in no way limiting the embodiments of the content of the invention.

[0019] FIG. 1 shows, in perspective, a system of collection via a membrane surrounding the resurgences(s).

[0020] FIG. 2 is a vertical cross-section of a variant using an open membrane surrounding a natural creek.

[0021] The device as shown in FIG. 1 is comprised of a flexible membrane 1, which surrounds the resurgence(s) 2 and is anchored to the sea bottom 5 in a suitable way such that it always remains centered on the resurgence 2 and reaching up to the surface 3 so that the upper part of the installation is always out of the water; the membrane is provided, in the lower part, with unattached parts forming valves, suitably
ballasted, enabling the seawater 7, which is heavier, to escape under the pressure of the freshwater 8 flowing from the spring.

[0022] At the immediate outlet of the freshwater, a system of deflectors 9 in metal or a synthetic material imposes a forced route on the flowing freshwater, in order to reduce turbulences and to induce a laminar flow to it.

[0023] The freshwater is removed by pumps 10 installed on a floating device 11 at the surface of the water.

[0024] The dimensions of the assembly are dependent upon each individual case but must be large enough to ensure a total value for the basin equal to or greater than half the hourly flow rate of the springs included while keeping an inertia potential capable of absorbing the variations, sometimes violent, of the karst network.

[0025] In the case where the resurgence 2 is located against a wall and if the morphology of the coast is suitable—if, for example, the freshwater intake occurs in a suitably sized creek—the membrane 1 can advantageously be placed between the points of the latter, with all the economic benefits arising from this (FIG. 2).

[0026] The collection method described can also be carried out in a rigid material (cement, concrete, metal or other). However, beyond the inherent extra cost, this type of construction has the drawback, in contrast to the flexible device, of favoring the nuisances due to the turbulent flow.

[0027] The flexible barrier installation (4) is provided with a system controlling the flow rate of the springs in real time. This system can, for preference, be constituted of one or more currentmeters installed at the outlet of the channels 2, which transmit the speed of the output current directly to the control center. Knowing the diameter of the channel, the flow rate can be derived from that in real time.

[0028] The barrier (circular or semicircular basin) must be equipped with an automatic control and alarm system able to control the opening the system and setting it to inoperative (feathering the barrier, for example) when the cumulative snapshot flow rate of the springs intercepted by said barrier exceeds a certain value determined for each installation after a prior study of the specific conditions for the network in question.

[0029] The implementation of the elements mentioned results in the device operating in a more effective and regular way, eliminating the random results that may have been observed up to now.

[0030] Moreover, the determination of the mathematical relationship between the available volume of the basin and the flow rate of the springs in question eliminates the causes of problems that have been observed during attempts of this type in the past.

1-9. (canceled)

10. A device for the collection of undersea freshwater resurgences enabling freshwater to be recovered from resurgences flowing below sea level, that includes a wall isolating the resurgences, at least one pump for removing the freshwater from inside the wall and a flow-rate control system that determines the resurgences flow-rate and sets each pump to inoperative when the cumulative flow rate of the resurgences intercepted by said wall exceeds a predetermined value.

11. The device of claim 10, wherein the predetermined value obey the formula

\[ V = \frac{Qh}{2} \text{ or } V > \frac{Qh}{2} \]

where \( Qh \) is the average hourly flow rate of the resurgences, and \( V \) is the total volume of water isolated by the wall.

12. The device of claim 10, wherein the wall is an hermetic wall.

13. The device of claim 10, wherein the wall is anchored to the sea bottom in such a way as to enable the upper part of the device to be permanently out of the water.

14. The device of claim 10, wherein the wall is equipped with valves located in the lower part of said wall, said valves enabling the seawater to escape from the wall.

15. The device of claim 14, wherein the valves are being formed by ballasted vertical vents in the flexible membrane.

16. The device of claim 10, wherein at least each pump is installed on a floating device at the surface of the water inside the wall.

17. The device of claim 10, wherein the flow-rate control system includes at least one currentmeter installed at the outlet of a resurgences and transmits the speed of said resurgence output current.

18. The device of claim 10, including an automatic control system that controls the opening of the wall as a function of the cumulative flow rate of the resurgences intercepted by said wall.

19. The device of claim 10, wherein the wall is constituted of a flexible membrane.

20. The device of claim 19, wherein the flexible membrane is kept at the surface of the sea by a floating element.

21. A device of claim 20, wherein the floating element is constituted of pipes or booms.

22. The device of claim 20, wherein the cumulative cross-section of the components of the floating element is determined such that the assembly emerges in all cases by a height of between 20 et 100 centimeters.

23. The device of claim 10, wherein the wall is made in a rigid material.

24. The device of claim 10, wherein the wall surrounds the resurgence.

25. The device of claim 10, applicable in the case where the resurgences are located in a creek, wherein the wall closes said creek by being held between the creek walls.

26. The device of claim 10, that includes deflectors positioned at the immediate outlet of the resurgence, said deflectors being arranged so as to impose a laminar flow on said freshwater.

27. A device for the collection of undersea freshwater resurgences enabling freshwater to be recovered from resurgences flowing below sea level, that includes a wall isolating the resurgences, at least one pump for removing the freshwater from inside the wall and a flow-rate control system that determines the resurgences flow-rate and set each pump to operate only when the hourly flow-rate of the resurgence is equal or less than twice the total volume of water isolated by the wall.

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