Sustainable Seawater Purification System Built in Piles Using Purifying Functions of Microorganisms and Tidal Energy

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Abstract

In closed sea areas in the world the eutrophication is being progressed day by day. Nowadays in closed sea areas in Japan it is hard to control the seawater quality in deep areas because of the poor oxygen seawater or the anoxic seawater. Aerobic microorganisms can contribute to decompose organic compounds in the seawater as long as they live to consume oxygen. As a result the oxygen decreases in deep areas. It is necessary to maintain that the seawater is clean and rich in nature for the sustainable development. One of methods is this sustainable seawater purification system built in quays and piles using purifying functions of microorganisms and the tidal energy (Dan et al. 2017). It is shown that this system can decrease Chemical Oxygen Demand (CODMn) in the seawater experimentally and can be utilized in order to purify the seawater from the depth to the shallows using this system built in piles partially around a pile and using this system built in quays widely along a quay. This system has following advantages. 1.Using the tidal energy –> "ecosystem" 2.Using the purifying functions of microorganisms, decomposing organic materials –> "ecological and natural without chemicals", 3.Capable of purifying the seawater in the shallow area, especially also in the deep area –> "useful" in closed sea areas 4.This system built in piles or quays is simple. Not to construct new quays but to construct the purifying room additionally. It costs less. –> "economical" The initial CODMn is almost 8 by putting sugar adequately in seawater and mixing (Fig. 9 and 10). The changing process of CODMn is checked by measuring CODMn according to JIS K 0102 (Japanese industrial Standards). In the case of seawater purification system CODMn is becoming smaller and it is found that this system can reduce CODMn in seawater. In future in order to construct this system built in piles or in quays in the field following procedure is considered, When the field site to construct this system is selected and the tidal range z is given. Because the velocity v in the vessel through gravels is sufficiently small for microorganisms to decompose organic compounds then v

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1. Introduction

In closed sea areas in the world the eutrophication is being progressed day by day. Nowadays in closed sea areas in Japan it is hard to control the seawater quality in deep areas because of the poor oxygen seawater or the anoxic seawater.

Aerobic microorganisms can contribute to decompose organic compounds in the seawater as long as they live to consume oxygen. As a result the oxygen decreases in deep areas.

It is necessary to maintain that the seawater is clean and rich in nature for the sustainable development. One of methods is this sustainable seawater purification system built in quays and piles using purifying functions of microorganisms and the tidal energy (Dan et al. 2017).

2. Methodology

It is shown that this system can decrease Chemical Oxygen Demand (COD_{Mn}) in the seawater experimentally and can be utilized in order to purify the seawater for the depth to the shallows using this system built in quays and partially using this system built in piles.

This system has following advantages.

1.Using the tidal energy → "ecosystem"

2.Using the purifying functions of microorganisms, decomposing organic materials → "ecological and natural without chemicals",

3.Capable of purifying the seawater in the shallow area, especially also in the deep area → "useful" in closed sea areas

4.This system built in quays or piles is simple. Not to construct new quays but to construct the purifying room additionally. It costs less. → "economical"

Since the tide is repeated daily continuously this period is supposed to be "a day". The seawater can move a day by the tidal motion and the total volume of the moving seawater a day V=BLv or $V=v\pi D^2{}_1/4$ then this discharge of the seawater flow Q is expressed as Q=vBL [m^3/day]. Q/L=vB=SvzD. The nondimensional parameter P=(Q/L)/(SvzD) can be introduced where S is a specific surface area of using gravels with a mean diameter d, v is a mean velocity of the seawater through gravels, z is the tidal range, D is the diameter of the circular gate and D_1 is the diameter of a cylindrical pile. When the field site to construct this system is selected the tidal range z is given. When the diameter d of using gravels is selected S is estimated because S is a function of d. By investigating the characteristics of P the discharge Q can be estimated per the set of gates, upper gate and lower gate.

3. Experimental approach

Microorganisms can decompose organic compounds in the seawater depending on the seawater temperature T(℃), DO (Dissolved Oxygen), the velocity of seawater through the gravels and so on. The experiment was performed changing these conditions. The size of the used tank is 60cm tall, 45cm wide and 120cm long. This system has two gates (Fig.1 and 4). There are the upward and downward purifications (Fig.2, 7 and 8) in piles or in the vessel of quay of decreasing COD_{Mn}. While the seawater moves in the pile through gravels it can be purified by the contact oxidation method with the help of microorganisms. Next the purified seawater moves out of the upper gate to the outer sea areas in case of the upward purification (Fig. 2). Then the tidal current can carry the purified seawater to another places (Fig. 6).

4. Results and discussion

The initial COD_{Mn} is almost 8 by putting sugar adequately in seawater and mixing (Fig. 9 and 10). The changing process of COD_{Mn} is checked by measuring COD_{Mn} according to JIS K 0102 (Japanese industrial Standards).

In the case of seawater purification system COD_{Mn} is becoming smaller (Fig. 9 and 10) and it shows that this system can reduce COD_{Mn} in the seawater in winter and summer. This quay can be utilized in order to decrease COD_{Mn} using the tidal energy and purifying functions of microorganisms.

The results are shown,

4.1 COD_{Mn} can be reduced greater In case of using Gravels with microorganisms than in case of without gravels

4.2 COD_{Mn} can be reduced greater in summer than in winter

4.3 In both cases of upward and downward purifications (flow direction) COD_{Mn} can be reduced

4.4 Microorganisms require sufficient oxygen concentration in seawater to resolve the organisms

In future in order to construct this system built in piles or in quays following procedure is considered,

①When the field site to construct this system is selected and the tidal range z is given.

②Because the velocity v in the vessel through gravels is sufficiently small for microorganisms to decompose organic compounds then $v<v_{min}$.

③The thickness t of gravels is supposed to be equal to z. Smaller thickness is not desirable because microorganisms can decompose more organic compounds proportionally to the area of the surface of gravels. S is inversely proportional to the diameter d of gravels.

④Accounting for above conditions the size of vessel B and L are selected then Q=z×B×L is estimated. v=Q/(BL) can be checked to be smaller than v_{min}, for example the velocity in the slow filtration.

⑤Using S, v, z, Q the nondimensional parameter P can be calculated. By investigating the characteristics of P the discharge Q can be estimated per the set of gates to plan this system.

5. Conclusions

The initial COD_{Mn} is almost 8 by putting sugar adequately in seawater and mixing. The changing process of COD_{Mn} is checked by measuring COD_{Mn} (JIS K 0102:Japanese industrial Standards).

In the case of seawater purification system COD_{Mn} is becoming smaller and it is found that this system can reduce COD_{Mn} in seawater.

This pile can be utilized partially around a pile and this quay can be utilized widely along a quay in order to decrease Chemical Oxygen Demand (COD_{Mn}) using the tidal energy and purifying functions of microorganisms.

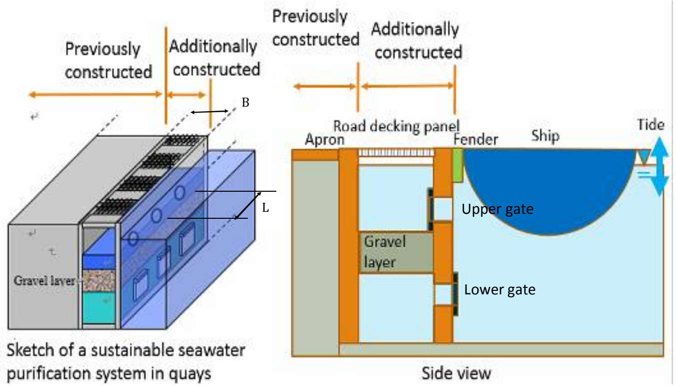

Fig.1 Sustainable seawater purification system built in quays

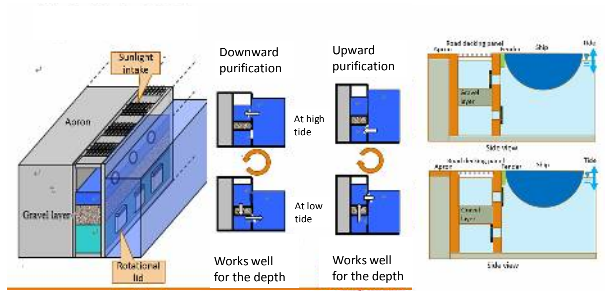

Fig.2 Upward purification and downward purification

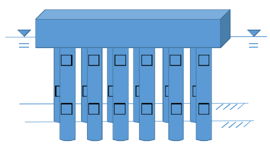

Fig. 3 Permeable breakwater using cylindrical piles

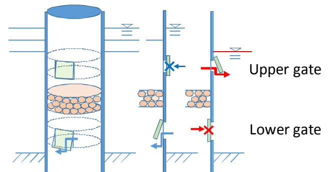

Fig. 4 Sketch of this system built in piles

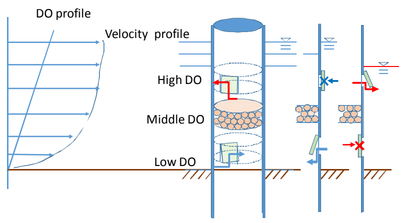

Fig. 5 DO profile and gravels position

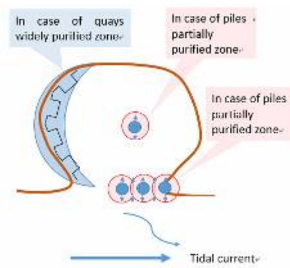

Fig. 6 Purification process and tidal current

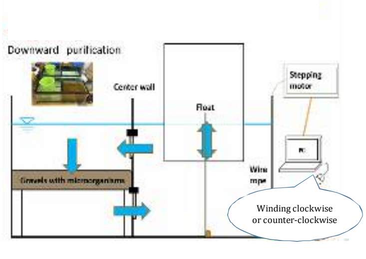

Fig. 7 Upward purification (in case of the float moving downward)

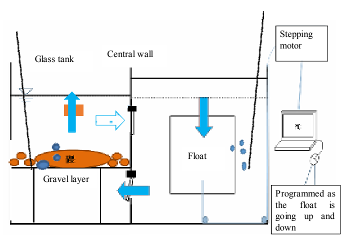

Fig. 8 Downward purification (in case of the float moving upward)

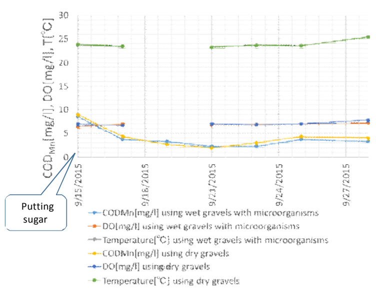

Fig. 9 Difference between the case using wet gravels and the case using dry gravels in summer

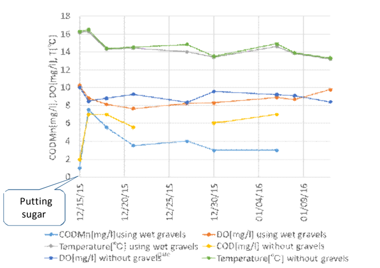

Fig. 10 Difference between the case using wet gravels and the case without gravels in winter

Reference:

K. Dan et al.:"Experimental Study on a Sustainable Seawater Purification System Built in Quays Using Purifying Functions of Microorganisms and the Tidal Energy in Closed Sea Areas", 37th IAHR World Congress, 2017.