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The Beneficial Reuse of Hypersaline Waste Water from Desalination Plants to Treat Harmful Algal Blooms

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Abstract

A number of technologies exist that offer the potential to control Harmful Algal Blooms (HABs). Many of these technologies involved the discharge of solids, chemicals, biological agents, or other foreign materials into waters experiencing HABS. Other technologies are also available that could control HABS through the manipulation of environmental conditions such as water salinity, temperature, light intensity and stratification. These potential control technologies would essentially accelerate or amplify the development of natural processes that terminate HABs. These technologies can be implemented over the entire range of conditions under which HABs occur and could limit the adverse environmental impacts to other organisms in the HAB impacted area.

One of these potential technologies involves the application of the hypersaline concentrate waste water from desalination plants over an area impacted by a HAB. The near surface discharge of the desalination plant hypersaline waste water could an effective means of HAB control by inducing rapid changes in water salinity and stratification. The expected environmental impacts would be temporary, limited in both duration and areal extent. No foreign chemicals, materials, substances, organisms or biological agents would be introduced into the environment. Added benefits would include the beneficial reuse of the hypersaline waste water from desalination plants, reduction of waste water loading to the local area of the desalination plant, and the potential to generate revenue for the desalination plants by the sale of waste water.

Keywords: HABs; Red Tides; HAB Controls; Desalination Plants; Beneficial Reuse

Introduction

On May 15, 2014, the National Oceanic and Atmospheric Administration (NOAA) issued the draft programmatic environmental assessment (draft EA) for the Prevention, Control and Mitigation of Harmful Algae Blooms (PCMHAB) program for public comment. In addition to the No Action alternative, in the draft EA, NOAA identified the alternatives as consisting of physical and chemical methods to prevent, control, and mitigates harmful algae blooms (HABs). The physical control methods alternatives consisted of [1]:

- Flocculation,
- Sediment resuspension, burial and removal,
- Cell harvesting and removal and
- Water column mixing for lakes and other partially or completely enclosed water bodies.

The chemical methods alternatives consisted of [1]:

- Native macroalgae and extracts,
- Barley straw,
- Biosurfactants,
- Hydrogen peroxide,
- Copper, silica and
- Extracted and/or purified algicidal compounds.

In addition to the alternatives considered in the NOAA draft EA [1], other technologies are feasible that could control HABs through the manipulation of physical or chemical conditions of the water. These technologies, including the following [2-4]:

- Water pumping units that could affect water salinity, stratification, and temperature,
- Systems that circulate, in a closed loop, either heated or cooled fluids that could alter water salinity, stratification or temperature,
- Arrays of banks of lights that could induce intense light conditions and
- Floating desalination plants that would manipulate water salinity, temperature and stratification.

An additional technology would be a modification and simplification of the floating desalination plant option. This option involves the beneficial reuse of the hypersaline concentrate waste water from desalination plants. This option would involve transporting the hypersaline waste water from the desalination plants and applying the hypersaline water over the surface of a HAB impacted area.

Discussion

Many of the approaches proposed for controlling HABS involve the introduction of chemicals, biological agents, and other materials to the water column to suppress the algal blooms [1]. However, a number of environmental factors are believed to be associated with the natural termination of blooms including [5-7]:

- Salinity changes,
- Temperature changes,
- Light changes,
- Chemical changes,
- Nutrient depletion and
- Dissolved oxygen changes.

Feasible technologies exist that could manipulate the environmental conditions supporting HABs, such as water salinity, temperature and stratification or light intensity, to an extent sufficient to potentially terminate a HAB [2-4].

Recruitment of new populations from offshore or other areas could introduce a HAB to a new area or re-introduce a HAB to a location

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where a HAB had previously been terminated [8]. To be effective control technologies would have to allow for the repetitive treatment of a HAB affected area to counteract the re-introduction of a HAB either through population growth of the remnant organisms, excitement from temporary cysts or population recruitment from outside areas [2-4].

An environmental concern that could be associated with the use of any HAB control technology would be the potential for significant adverse impacts on the local marine organisms, including mortality [1]. Through logistical and timing controls implemented during treatment, such as limiting the manipulation of water salinity, temperature, and light intensity within ranges that can be tolerated by other organisms, adverse impacts on other organisms, including the mortality of other marine organisms, could be reduced while still terminating a HAB.

In addition to the potential technologies previously proposed [1-4], the beneficial reuse of the hypersaline concentrate waste water from desalination plants offers the potential for the treat or suppress a HAB. Similar to the discharges of floating desalination plants previously proposed [2-4], the application of the hypersaline waste water from land-based desalination plant could temporarily increase the salinity to levels that are not tolerated by the HAB organisms. The application of the hypersaline waste water could disrupt water column stratification through advection currents, would help to disrupt the HAB. The treated area could be controlled through the rate and volume of the hypersaline water discharged and the surface area over which the discharge is administered.

An attractive feature of the beneficial reuse of the hypersaline concentrate is that the waste water is continuously generated while the desalination plant is in operation. The hypersaline waste water could be transported from a land-based desalination plant and transported to, and applied over a HAB impacted area repeatedly. This continuous generation would allow for the repetitive application of the hypersaline discharges to counteract the re-establishment of a HAB; either through recruitment from outside areas or population growth from the remnant population or cysts.

Marine organisms have an upper limit to the salinity that can be tolerated and survived. For example, for *Karenia brevis* (*K. brevis*), a Florida HAB causing dinoflagellate, the upper salinity limit that the organism could be acclimated to was 45 practical salinity units (psu) [9]. Under increased temperatures (i.e., above 23°C), *K. brevis* cultures began exhibiting poor growth when the salinity was increased above 36 psu [9]. The salinity levels of the hypersaline waste water from land-based desalination plants are greater than the upper limit that HAB species can typically tolerate. The salinity tolerance of other marine resources in the area should be considered and the rate and volume of the hypersaline discharge can be controlled to help reduce the potential for adverse impacts on other organisms.

The beneficial reuse of the hypersaline waste water from land-based desalination plants could avoid a number of potential adverse impacts associated with other HAB control technologies. Adverse impacts that could be avoided include [1-4,10,11]:

- The introduction of solids that could blanket or bury natural sediments.
- The introduction of chemicals that could persist in the environment and possibly is deleterious to other organisms.
- The introduction of foreign biological agents or other organisms that also could persist in the environment and possibly be deleterious to other organisms
- Alter physical factors such as temperature and turbidity and
- Introduce the potential for impingement and/or entrainment and/or entrapment.

The adverse environmental impacts related to the use of the hypersaline waste water from land-based desalination plants to control HABs would be temporary. The duration and areal extent of the salinity increase can be controlled by the rate and volume of the hypersaline discharge. No long-term adverse environmental impacts should be created. In addition, the discharge of the hypersaline concentrate from desalination plants could be controlled to limit the salinity of the discharges to ranges that could disrupt a HAB while limiting the impact on the rest of the marine environment. As opposed to a number of the approaches that have been advanced to treat or control HABs, the discharge of chemicals, solids (such as clay or straw), or organisms or biological agents to the environment would be avoided.

The use of the hypersaline waste water would also provide a number of benefits to the desalination plant and the local environment of the desalination plant. First, the use of the hypersaline concentrate would represent a beneficial reuse of what is currently the waste water from the desalination plants. Second, the loading from the waste water discharge from the desalination plant to the local environment would be reduced. Third, the desalination plant could experience financial benefits from the beneficial reuse of the hypersaline concentrate and the associated reduction in waste water volume needing disposal.

Conclusions

A number of technologies exist that offer the potential to control HABs. Many of these technologies involved the discharge of solids, chemicals, biological agents, or other foreign materials into waters experiencing HABS. Other technologies are also available that could control HABS through the manipulation of environmental conditions such as water salinity, temperature, light intensity and stratification These potential control technologies would essentially accelerate or amplify the development of natural processes that terminate HABs.

These control technologies are feasible and can be implemented over the entire range of conditions under which HABs occur. Changes in environmental factors, such as water salinity, temperature, stratification and light intensity are associated with the natural conditions that terminate HABS. The beneficial reuse of the hypersaline concentrate waste water from a land-based desalination plant is suggested as a feasible approach to controlling HABs because of the ability that is offered to increase water salinity and, possibly, affect water stratification.

Temporary adverse environmental impacts are possible from the reuse of the hypersaline concentrate from desalination plants. The severity of these impacts can be limited through the control of the rate, volume, duration and area of the discharges. With the continuation operation of the desalination plant the application of the hypersaline discharge can be repeated a number of times to prevent the re-establishment of a HAB after the initial treatment. A number of adverse impacts associated with other potential HAB control technologies would be avoided. No foreign chemicals, materials, substances, organisms or biological agents would be introduced into the environment. The beneficial reuse of the waste water from desalination plants would reduce the local adverse impacts associated with discharges from the desalination plant and could provide some financial benefit.

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