Hydrocarbon Bioremediation in Constructed Wetlands

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Fall 2018

Abstract

The rationale of this research is to investigate three categories of bioremediation alternatives applied to constructed wetlands. The remediation methods were evaluated by comparing average effectiveness of the experimental treatments with the control group treatments. Control groups that included constructed wetlands that had no additives and one that had only hydrocarbons introduced and the experimental group that included peat moss, micro blaze, and a combination of peat moss and micro blaze remediation additives. Success was considered by calculating the values that characterized water, soil, and vegetation quality factors to try to create a general image of the constructed wetlands physical condition. There is no accurate or right definition that can illustrate a healthy wetland because of the diversity that this ecosystem bears, but evaluations and quantification characteristics over time can assist evaluate the condition of health to conclude if a region is healthy or unhealthy. Further research is warranted to help define and optimize alternative methods and the long-term performance capabilities as well as the state of this beneficial wetland ecosystem.

Introduction

There are over 4.9 million liters of petroleum being spilled into United States waters every year on an average. The U.S. Department of Energy infers the origination of this spill to be leakage from either the vessels transporting crude oil and/or the pipelines that transect the ocean floor that have experienced a leak. In the event of a major spill, that number could easily double. Oil spills, when severe enough, often reach the shore and have impacts on the biota (vegetation and fauna) along the coastline including wetlands. In the Texas gulf coast, transport of heavy crude oil can be particularly frequent and with high potential of leakage can be harmful to the ecosystem. For instance, the crude oil from the 2016 Deepwater Horizon spill is still having negative effects on the wetland soil redox functions (B.M. Levine, 2017).

Constructed Wetlands are at risk from spills and leaks just like naturally occurring wetlands. But defining the impacts from leaks is less developed. Constructed wetlands are used for many reasons including, increasing water quality and habitat restoration. Natural wetlands that have been removed, can find great value in the introduction of constructed wetlands. In some areas such as California, there can be up to 90 % of natural wetland loss due to urbanization and changes in land use (Bertoldi & Swain, 1996). Efforts to replace these removed ecosystems are becoming more frequent. Constructed Wetlands are also a well-established and long practiced wastewater treatment option. Though studies evaluating the usefulness of constructed wetlands in spill and leak response are less developed. Constructed wetlands are becoming more frequent and are becoming an important part of the coastal ecosystem in the United States. Spill research regarding these introduced habitats should be further explored due to their great worth. Since constructed wetlands aid in restoring water quality, preventing soil erosion, promoting flood control, increasing diversity in fish and wildlife, as well as serve as recreational areas for humans, their restoration and protection should be of the utmost importance.

Bioremediation as a spill response technique paired with constructed wetlands, to undo the adverse effects from oil on sensitive habitats, is also a mostly unexplored topic. Traditional remediation techniques can occasionally be detrimental to the existing vegetation and when located in hazardous areas, traditional remediation becomes impossible. This study aims to evaluate the effectiveness of long practiced bioremediation alternatives on constructed wetlands. The Gulf of Mexico is considered a hot spot for spills since it experiences more spills than other area (LIVE SCIENCE 2018). There is a wide array of bioremediation techniques used, for the study including *Peat moss* and a wetting agent called Microblaze were used.

Peat moss is a collection of around 300 types of moss with a very high water holding capacity and has the tendency to acidify surroundings. Use of peat moss in hydrocarbon pollution has shown that a high level of biological remediation can be achieved (Porta, Micle, and Babut, 2013). Microblaze is a collection of naturally occurring bacteria that degrade complex hydrocarbons and produce harmless byproduct. Non-pathogenic *Bacillus* bacteria has been known to remove petroleum hydrocarbons and eliminating the toxicity in contaminated soil after bioremediation (Steliga, Jakubowicz, & Kapusta, 2012)

Between November 2014 and May 2015, treatments were set up with different bioremediation alternatives to evaluate the soil, water and vegetation quality in five constructed wetlands. Experimental set up included two control (CW-A and CW-B) and application of three experimental alternatives (CW-1, CW-2 and CW-3) to contaminated soils. Throughout the study period multiple site assessments were conducted every week on each of the five small wetlands.

The purpose of this paper was to examine three different combinations of bioremediation alternative applied to these constructed wetlands. The remediation techniques were compared in terms of determining an average effectiveness by comparing baseline values from the control group to experimental groups. The baselines were defined by measuring values that evaluated soil, water, and vegetation quality parameters to attempt at developing a general picture of the constructed wetlands health. There is no “correct” definition that can describe a healthy wetland due to the extreme diversity that this ecosystem exhibits, but comparisons and measuring attributes over a period can help evaluate the state of health to determine if an area is improving, neutral, or declining in health or how abundant the organisms are.

MATERIALS AND METHODS

Site evaluation

Study location: Texas A&M University -Corpus Christi (TAMUCC), National Spill Control School

The entirety of the data collection and observation process was done on the TAMUCC campus near the National Spill Control School. The constructed wetlands were arranged on the south side of Ward island located in Oso Bay. The Oso is a very productive estuary with high biodiversity(REF). There is an abundance of oyster reefs that promote fishing (red and black drum and seatrout) and is bordered by the Hans and Pat Suter Wildlife refuge which encourages birding and acts as a refuge for animals traveling long distances. This area is comparable to many other bays and inlets along the Gulf of Mexico. The site received very little disturbance by passerby being located away from walking paths.

Figure 1. Texas A&M University-Corpus Christi campus. Constructed wetlands were assembled in the north east side of campus between the Oso Bay (top) and the Corpus Christi Bay (bottom)

Figure 2. The Coastal Bend Bays and Estuaries Program property where the cordgrass for the study was harvested. The large spartina mat is pictured above.

Vegetation Collection Site: Coastal Bend Bays & Estuaries Program (CBBEP)

The hydrophytic vegetation chosen for this study was kindly donated by the CBBEP. Along the coastal bend region of south Texas, there are over 75 miles of protected plant and animal habitats that are native to the region and support biodiversity and productivity. There is a variety of marsh and wetland plants that were available for harvest and study. Cordgrass is one of the most common plants in coastal salt marshes. Wetlands can have large patches of cordgrass all over the Texas gulf coast and are even found as far north as Maine and similar genus can be found globally. *Spartina spartinae* was chosen because it has such a wide range, and has potential to have meaningful results in areas outside of the Texas Gulf Coast since its range spans from the Gulf of Mexico to Argentina.

Phase 1: Supply Collection and Wetland Construction

The collection process required gathering: vegetation and soil for the construction of the five wetlands, remediation agents to measure the effect on wetland health, and hydrocarbon pollution sources to act as the hazardous waste leak. All materials were collected from the Corpus Christi. The pollution source being a simulated oil spill consisting of eagle ford shale crude oil. Eagle ford shale oil is a heavy crude that is found throughout Texas and is one of the most actively drilled oils in the state of Texas outing it at an increased risk for leaks and spills.

The constructed wetlands were evaluated using five different small wetland samples. The topography of the wetland was designed to mimic natural conditions and was built with extra soil that was collected from the CBBEP. The constructed wetlands were assembled inside a double containment unit to reduce the risk of a leak occurring. The outer pool comprised of a round durable polyethylene measuring 4.92’ X 11.4”. The inner pool consisted of a 15-gallon durable rubber tub (9.5” H x 26.25”) to be the housing unit for the constructed wetland. The pools were arranged to have the control pools in one area and the experimental set in another cluster all within two feet of another wetland. The pools were also labeled CW- A and CW-B for the control groups and the experimental pools were labeled CW-1 to CW-3 to differentiate. The cordgrass was next to be introduced. Once at CBBEP, large expanses of spartina mats were used to collect the bunches of grass that had a diameter of around 8 inches. The plants were taken from mats that had at least 10 yards between collection locations. Keeping samples relatively homogenous with the larger matt but also variant enough to not diminish the health of the grove. The cordgrass was transported and planted into the five constructed wetlands at TAMUCC. Five days of observations took place to ensure that the plants were all in similar health post introduction to the new ecosystem.

All but one of the constructed wetlands (CW-A) received the EFS crude oil “spill”. 20 mL of Eagle ford shale crude oil was poured into the water and leached into the vegetation by means of the soil to simulate a leak. Current remediation techniques allow time for the spill to evaporate, to follow similar practices, the spill was given 24 hours to “breathe” and allow for natural remediation processes occur.

At the completion of the observation period, the constructed wetlands deemed in good health allowing for the newest environment change, bioremediation components. CW-1 consisted of 20 mL of *Peat moss* that was sprinkled in by handfuls covering the entire oil effected area of the water and soil. CW-2 had the *Micro blaze* wetting agent that was sprayed into the area using a hand pump to allow for even coating along the impacted area as per the instructions for the *Micro blaze* product. CW-3 consisted of a mixture of *Peat moss* and *Micro blaze* with concentrations of 10 mL and 6 mL respectfully, following the previous pattern of covering the oil with the additives. The contents of the constructed wetlands are illustrated in the table below

	Constructed Wetland	Substances
Control	CW-A	No additives
	CW-B	• 20 mL Eagle ford shale crude oil
Experimental	CW-1	• 20 mL Eagle ford shale crude oil • 20 mL *Peat moss*
	CW-2	• 20 mL Eagle ford shale crude oil • 12 mL *Micro blaze*
	CW-3	• 20ml Eagle ford shale crude oil • 10 mL *Peat moss* • 6 mL *Micro blaze*

Phase 2: Data Collection and Observations

The method of determining the health of the wetland was done so by combining data points from water, soil, and vegetation. Wetlands are defined by these characteristics so evaluating their health using multiple factors will create a more robust generalization of the wetlands. Water (salinity, dissolved oxygen, turbidity), soil (pH), and vegetation (survey) were done to evaluate the wetlands average health.

Water

To determine the quality of water, measurements of the salinity, dissolved oxygen and the turbidity were taken. These factors can be very telling in determining the state of an ecosystem. Salinity is important because maintaining a healthy salt to freshwater ratio in brackish ecosystems supports productive ecosystems and thresholds that are ideal for organisms that could have a sensitivity to drastic change. Dissolved oxygen measures the amount of available oxygen in water, which is also a determining factor for animals. Turbidity is measured for determining how much light enters through the soil and water of the constructed wetland and can dictate idea ranges for animals and oxygen concentrations in the water.

Soil

Determining soil health can be evaluated with properly defining the soil type. Having healthy soil is important to support the animal life that rely on it, especially after a hazardous leak. Soil acidity is particularly important because changes in soil pH can initiate dynamic changes in soil chemistry. Especially when working with factors that are notorious for affecting soil pH like peat moss.

Vegetation

Vegetation is a good indicator on if a wetland is in a healthy condition or not. observations of plants as well as monitoring if any other disturbances occurred. This could potentially indicate that the wetland is healthy and productive. Based on observations of the wetland cordgrass in question, a rating of 1-5 (1 being lower health and 5 being an optimal vegetation state) was given based on a series of factors. Growth rate and how swift the establishment to a new habitat was taken. Leaf color and turbidity- monitoring for chlorosis or phytotoxicity, wilting, and strength of the grasses. Moisture content of grass stalks and soil were also observed. The quality of detritus that was established in the constructed wetland. Observations were made multiple times a week and recorded to develop a profile of the state of the constructed wetlands during this study.

Phase 3: Clean-up/ Disposal and Final Observations

The remaining bunches of spartina were collected and gently shaken above a clean shower curtain to catch the debris falling until the soil was adequately removed from the roots. Observations of organisms were recorded and photographed for evaluation to indicate if increased biodiversity is present in the wetlands.

RESULTS

Water

Sphagnum is established to have remediation properties since it maintained the salinity levels of water in CW-1 (37.74). The control series revealed that the baselines for highs and lows of salinity differed. The lowest averaged salinity levels were about 35 parts per thousand (ppt), and the unremediated CW had the highest salinity at 39 ppt. CW-2, which had the micro blaze wetting agent, also exhibited lower salinity levels of about 37.41. CW-3, which contained a mixture of peat moss and Micro Blaze, also had low salinity levels of about 37.52.

However, the dissolved oxygen (DO) concentration for all the constructed wetlands were lower than the accepted range of 4 mg/L to support fish communities. The control group yielded a 2 mg/L for the DO, which was the highest in the experiment. The unremedied CW had the lowest DO of 1.09 mg/L. CW-1 exhibited significantly higher DO levels, about 1.49, and CW-2 had even higher levels of DO concentration (1.64). CW-3 also recorded increased DO concentration levels of about 1.56.

Most wetlands have low NTU, and the control series revealed the unaffected CW because it had the lowest average at 12 NTU. The negative control had a higher suspended particulate matter concentration averaging 25 NTU. The experimental design had a high turbidity associated with peat moss of 35 NTU closely followed by the microbial community and the combination with the same average. The oil only exposed constructed wetland (CW-B) had a turbidity of 25 NTU.

Soil

The unaffected CW retained the lowest average pH range throughout the study of 7.49 pH while the CW with pollution and no remediation had a relatively high pH of 7.58. The experimental series produced the CW with the highest pH (7.6) associated with the increased acidity of the remediation additive peat moss. The microbial community yielded the lowest of the experimental group with an average of pH of 7.53 and the combination of peat moss and micro blaze yielded somewhere in the middle with a PH of 7.57.

Vegetation

The results revealed that the CW that had no interference had the highest plant health with an average rating of 4.9 on a 1-5 scale. On the other hand, the oil exposed CW had the lowest health at 3.1. The experimental group led to the development of startling insights; this group showed that the averages that measured the total health over the duration of the experiment were relatively improved. The healthiest plants came from the CW that consisted of the peat moss and a microbial community followed by the CW that had only a microbial community and the peat moss CW followed.

Figure 3. Microscope photographs of Enchytraeidae, or pot worms, visible in the soil of CW-3, containing a mixture of bioremediation tactics

Figure 4. Evidence of mycorrhizae communities from CW-3 in the root systems

DISCUSSION

Bioremediation in constructed wetlands

The effectiveness of bioremediation on constructed wetlands health post oil spill remains unclear. Identification of specific effects that determine the status of the soil, water, and vegetation may facilitate novel remediation techniques that could improve responses to currently available therapies. In this study, we measured traits that define a series of attributes about the soil, water, and vegetation of constructed wetlands to identify bioremediation effects on wetland health. Through a combination of measurements on different aspects of the small samples of ecosystem, we identified a mixture of remediation additives as being more effective in restoring wetland health after a hydrocarbon spill.

Water

remediation worked because the water supports the proper living conditions for the organisms that use the wetlands as their primary habitat bioremediation has proved to be effective in increasing the DO levels in water in the experimental groups. bioremediation proved ineffective because the water had high turbidity levels.

The above developments prove that bioremediation has the capacity to maintain ideal salinity levels in water. The results reveal that, in general, the pools that underwent the process of bioremediation had better levels of salinity when compared to CW-B, which did not receive any type of treatment. Salinity is important because maintaining a healthy salt to freshwater ratio in brackish ecosystems determines the threshold for life that can be sustained. Studies indicate that salinity is amongst the most widespread soil degradation processes in both native and agricultural soils (Canfora, Benedetti & Francaviglia, 2015). Saline soils are surroundings that are typified by high salts concentrations and an irregular spatial and temporal water distribution. These excess salts modify water and nutrients availability for both microorganisms and plants (Canfora, Benedetti & Francaviglia, 2015). Accordingly, bioremediation appears to reduce the salt concentration levels in water and the soil, thus, improving the general health of the constructed wetland.

The dissolved oxygen (DO) concentration for all the constructed wetland were lower than the accepted range of 4 mg/L to support fish communities. Understanding this phenomenon is important because the control group ought to have DO levels that can sustain aquatic life. Instead, the control group yielded a 2 mg/L for the DO, which was the highest in the experiment while the unremedied CW had the lowest DO of 1.09 mg/L. The experimental group that had the highest dissolved oxygen concentration was the microbial community and the lowest was the peat moss remediation group. Understanding why DO concentration in CW-A was lower than 4 mg/L is important because it would also reveal the primary cause of the low DO levels, considering the fact that hydrocarbon contamination was not the cause for this development. Also, finding a way to make sure that the water with hydrocarbon contamination is purified to a level where it can support aquatic life can be a significant milestone in the field of science. Such a development would reverse the effects of hydrocarbon contamination in the areas that have been worst hit.

Turbidity

There were disparities in the results of all the five pools regarding salinity levels. The study established that sphagnum has remediation properties because it maintained the salinity levels of water. The remediation capabilities of sphagnum emerged where the experimental group had similar average salinities to the control group. However, finding a way to ensure that the salinity levels of water in both the control and experimental groups are somewhat equal is important. This advance would enable scientists to completely restore the areas that have been hardest hit by hydrocarbon. Finally, developing an account of why bioremediation can remedy the salinity and pH levels of water and soil respectively but fail to better the turbidity levels needs further enquiry. Bioremediation proved to be ineffective because the water had a high turbidity level. Most wetlands have low NTU, and the control series revealed the unaffected CW because it had the lowest average at 12 NTU. The negative control had a higher suspended particulate matter concentration averaging 25 NTU. The experimental design had a high turbidity associated with peat moss of 35 NTU followed by the microbial community and the combination with the same average as the oil only exposed CW of 25 NTU. Reducing the levels of turbidity is also critical to the survival of organisms in water. Turbidity has an effect on the organisms that are directly reliant on light, for instance, aquatic plants since it reduces their capacity to carry out the process of photosynthesis (NOAA, 2018). This development, in turn, has an effect on other organisms that are reliant on these plants for oxygen and food. In this regard, scientists usually think about turbidity of the water in association with different aspects to get an improved appreciation of its basis and effects.

Soil

Bioremediation appears to have resulted in a decline in the pH level of soil, which means that this approach can be used to remedy the hydrocarbon effects of oil spillage in wetlands. The control series yielded extremes for their cases. The experimental group yielded varied averages that were relatively neutral.

Determining soil health and properly defining the soil of an area you can have a great deal of knowledge based off just that. The health of some animals will be especially sensitive after dealing with a spill so having healthy soil is important to support the organisms that rely on it. Soil acidity is particularly important because changes in soil pH can initiate dynamic changes in soil chemistry especially when working with factors that are notorious for affecting soil pH.

The soil pH results show that even if the improvements are minimal, bioremediation has a certain effect on decreasing the level of soil pH in areas with hydrocarbon contamination. Studies indicate that soil pH and organic matter have a noteworthy impact on soil functions and the availability of plant nutrient (McCauley, Jones & Olson-Rutz, 2017). In particular, pH influences availability and solubility of plant nutrients, performance of pesticides (which comprise herbicides), and the decomposition organic matter.

Further research to understand how bioremediation can be used to reduce pH levels to the level of the control group should be conducted. Bioremediation appears to have resulted in a decline in the pH level of soil, which means that this approach can be used to remedy the hydrocarbon effects of oil spillage in wetlands. The soil measurements show that further research is required to better the knowledge surrounding the connection between bioremediation and decreasing the pH of hydrocarbon contaminated soil. Even if the improvements are minimal, bioremediation has a certain effect on decreasing the level of soil pH in areas with hydrocarbon contamination. Studies indicate that soil pH and organic matter have a noteworthy impact on soil functions and the availability of plant nutrient (McCauley, Jones & Olson-Rutz, 2017). In particular, pH influences availability and solubility of plant nutrients, performance of pesticides (which comprise herbicides), and the decomposition of organic matter. In this regard, determining the health of soil and properly defining the soil of the area that a scientist is studying may lead to the development of a great deal of knowledge. Further, the wellbeing of some animals is especially sensitive after an oil spill or leak. Therefore, having healthy soil is fundamental to supporting the organisms that that depend on it. Soil acidity is especially important since changes in soil pH can set off dynamic shifts in the chemistry of soil particularly when working with issues that are known for affecting soil pH.

Vegetation

Bioremediation appears to have improved the constructed wetlands since the plants that went through bioremediation had significantly higher health ratings when compared to the oil exposed constructed wetlands. Through the health surveys and observations regarding the plants health, the scientists averaged ratings to establish the plant health. Images support the fact that that the peat moss dominated constructed wetland (CW-1) had less life being supported by the soil, water, and vegetation of this wetland. Evidence of crabs, insects, and miscellaneous organisms utilized the resources of the microbial community and the peat moss to determine adequate living

Although there was no evidence of altered plant health, there were interesting things that were observed in the roots. Evidence of mycorrhizae communities forming and what appeared to be worms in the soil adding to the array of organisms that was using the experimental constructed wetlands to support biological life emerged. Fungus was also seen in various stages of germination and growth in the CW that had the combination of microbial communities and peat moss had the most instances of fungal life and the only observed instances of the small worms within the remaining soil and plant material and other organisms.

Further research is required to reveal ways of bettering the health of plants in hydrocarbon areas. The research proves that bioremediation improves the constructed wetlands because the plants that go through bioremediation have significantly high health ratings when compared to the oil exposed CW. The health surveys and inferences about the plants health determine the plant health to a large extent.

More research should be conducted to establish the true impact of bioremediation on hydrocarbon removal in wetlands. Also, further research will unearth new ways of using bioremediation to minimize the effects of damage done on the environment in the realm of clean up. The findings of the study appear to be somewhat inconsistent and inconclusive regarding the effects of bioremediation on hydrocarbon removal in wetlands.

ALTERNATIVE OIL SPILL CLEAN UP APPROACHES

Alternative oil spill cleanup methods are gaining popularity due to their efficiency. Current spill containment technologies employed to clear out oil in coastal surroundings are: the utilization of booms, sorbent booms, hard booms, skimmers, fire booms, dispersants, in situ burning, vacuum trucks, and chemical cleaners. Nevertheless, a lot of variables have a direct and indirect impact the cleaning reaction, and it is imperative to have a lucid appreciation of the variables that are concerned (Walther III, 2014). These oil spill reaction variables comprise size of spill, water temperature, period to clean, resources at risk, wind speed, habitats at risk, economics at risk, masses at risk, responsible party, public interest, and having adequate money to conduct a smooth process. Oil spill reaction planners classify the threat of spills in three degrees; that is, Tier 1, 2, and 3. These degrees are arranged in an arrangement that considers the capacity of cleaning companies to react to an event, and the predictable quantity of oil leaked (Walther III, 2014). A successful oil leak reaction plan entails accepting the ecological, social, natural, and financial effects in the site of possible oil leaks. Oil leaks pose a threat to numerous organisms; in this regard, knowing the precise things that can be harmed is assists responders to comprehend the reserves that are at jeopardy.

Accordingly, the National Oceanic and Atmospheric Administration (NOAA) affords Environmental Sensitivity Index (ESI) maps to response planners on their site. These ESI maps reveal the categories of resources that are at risk in a region that is in danger of being affected by an upcoming oil leak (Walther III, 2014). ESI maps reveal all the habitats, plants, animals, historical sites, shoreline type, and recreational spaces that should be calculated prior to coming up with a leak response arrangement for a possible spill site (Walther III, 2014). If an upcoming oil leak is to take place, ESI maps help oil leak planners to place priorities to their response endeavors. Cyclic sensitivities for species close to a possible spill site are exhibited on ESI maps. ESI maps also offer information on specific species that are most susceptible, and also comprise all contact information for crisis staff that would supervise a spill in the prospective area, as shown below.

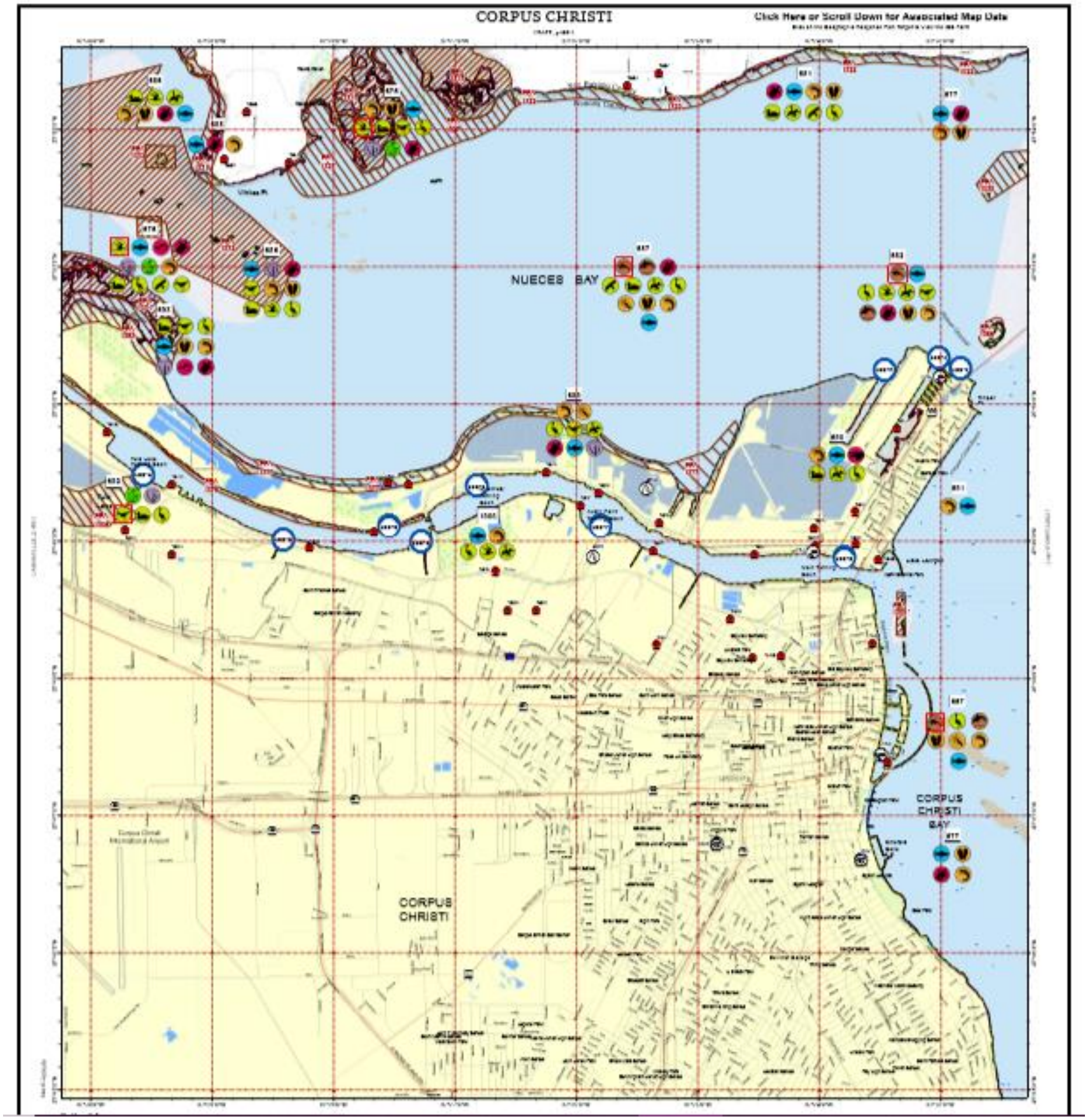

Figure 5. ESI map showing the areas of sensitivity and biodiversity in the study location in Nueces Bay of Corpus Christi.

All oil that is spilled in the ocean ultimately begins to transform physically in a method known as weathering. After oil weathers, it shifts the manner in which oil appears. Weathering can take place at numerous differing degrees and a stout quantity of variables that impact the weathering of oil in the ocean (Walther III, 2014). These variables comprise the sunlight on the leak site, temperature of the ocean, behavior of the sea, and the quantity of microbes that are accessible to devour the oil. Spill responders should have an apparent understanding of the manner in which spilled oil weathers, so as to select the best plan of response and equipment for eliminating the oil from the ocean. Also, oil spill responders ought to have adequate knowledge regarding oil trajectories, response actions, and response plans.

Considering the above ideas, once all strategies and risks for a specific area are evaluated and comprehended, oil spill reactors get ready for response actions by regularly enhancing response capability and promptness. Readiness and ability entails preparing all response staff, constantly undergoing response drills, and keeping equipment and supplies inventory to be used for leak responses in good condition (Walther III, 2014). Any preparation that engages oil spill staff should address any probable spill circumstances for a particular location.

CONCLUSIONS

When excessive oil spills occur, the oil often reaches the shore and affects vegetation and fauna alongside the coastline. Heavy crude oil may be particularly damaging to a susceptible wetland environment. Several studies have clearly indicated the risk of such oil spills on naturally occurring wetlands, similarly these spills place constructed wetlands at risk as well. Constructed wetlands improve water quality and help replenish the regions that were once abundant in natural wetlands thereby allowing area around it to become fit for human habitation regarding urbanization and land usage. Although studies assessing the importance of constructed wetlands in leak response are not comprehensively developed, and since these systems are developing into an important element of United States' coastal ecosystem, research concerning effects of oil spills on constructed wetlands ought to be explored further.

Additional research is required to help define and optimize alternative remediation approaches that exhibit lasting performance capacities to restore a wetland ecosystem. This current study focuses on assessing the effect of three different combinations of bioremediation methods in remediating constructed wetlands. These remediation approaches were evaluated in terms of standard effectiveness by comparing baseline concentrations from the control group to experimental clusters. Success was considered by calculating the values that characterized water, soil, and vegetation quality factors to try to create a general image of the constructed wetlands physical condition. No accurate right definition can illustrate a healthy wetland because of the diversity that this ecosystem bears, but evaluations and quantification characteristics over time can assist evaluate the condition of health to conclude if a region is healthy or unhealthy.

The results indicate that the health of the plants and soil maintained traits that are the same as the natural setting. Little change was noted in the start and the end of the 'reference' pools that were not exposed to the oil contamination. Contrary to that, the system with oil contamination with no remediation additives exhibited below average health quantities as the pools that contained the bioremediation additives. The soil pH was relatively close to neutral and was somewhat acidic. Salinity was both closest and lowest to the anticipated 35 ppt that exists in brackish waters. The dissolved oxygen maintained high with plenty of available oxygen in the water for respiration. Though the waters turbidity remained the lowest. There is fewer particulate matter in the water constricting light from penetrating through the water. The vegetation survey yielded the highest health for this CW with consistent health throughout the study. Alternative oil spill cleanup approaches are gaining popularity due to their efficiency. Spill containment technologies employed to clean oil in coastal surroundings are a lot of variables can impact the cleaning reaction in either a direct and indirect manner, and it is imperative to have a lucid appreciation of the variables that are concerned.

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