Lehi City Irrigation Asian Clam Eradication
Project ID: CEEn_2018CPST_010

by

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Final Report

Submitted to

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April 10, 2019

Executive Summary

PROJECT TITLE: Asian Clam Eradication
PROJECT ID: CEEn_2018CPST_010
PROJECT SPONSOR: Lehi City Water Department
TEAM NAME: Los Hermanos

The Lehi City Asian Clam Eradication project proposed a plan to manage the Asian Clam population found in Lehi City's Pressurized Irrigation system. The objective was to find the most cost-effective and efficient chemical treatment or a combination of different types of treatments (e.g. copper sulfate treatment while periodically flushing out the system). This was done to limit the damage done in the system, control the Asian clam population, and maintaining system operation. In addition, we took into consideration the research done in the past, and the most feasible solutions were selected.

In conjunction with the Lehi City Water Department, we set up a laboratory in the shed located in North Lake Park. The lab was used to test the EarthTec. This experiment determined whether treatment with EarthTec is effective for Asian Clams.

This first part included modeling the system, setting up the laboratory, and performing the experiment to observe how the clams reacted to treatment. Unfortunately, it was difficult to distinguish whether clams were alive or dead. For this reason, we assumed that clams were alive if they move and dead if they did not. We recorded them before and after treatment and observed and measured the difference in motion.

After carefully observing the motion, we analyzed the data and presented the results in this report.

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Introduction

The city of Lehi is experiencing problems with Asian clams which is an invasive species of mollusk in the pressurized irrigation system. The Asian clam is capable of self-fertilization and one clam can lay up to 70,000 eggs per year. The presence of the Asian clam in the system can cause problems such as a decrease in water pressure because of clogging, damage to the pipes, and damage to the pipe outlets. The city of Lehi manages the population of Asian clams by injecting chlorine into and flushing the system periodically. The flushing is done during the winter since there is a lower demand for irrigation water. The city of Lehi can not turn off the irrigation system because it is connected to the fire hydrants.

There have been different reports done to manage the population of Asian clams. Some of the methods that the reports mention are: chlorine, filters, and copper sulfate. A report done By Hansen Allen and Luce, asserts that the most effective way to control the population of Clams is by injecting Copper Sulfate into the system. Copper consumption can be harmful to humans and mammals; thus, if copper is used it must be monitored so that its concentration does not exceed 1.3 mg/L. This restriction is set by the EPA so the concentration of copper does not harm any part of the environment.

A salesperson contacted Lehi City with an offer of a treatment made with a copper sulfate solution called EarthTec for the eradication of Asian Clams. He claimed that his product is the most effective on the market. He recommended 1-2 gallons of Earthtec for one million gallons of water; this concentration would result in 60-120 ppm Cu++.

Our study evaluated EarthTec using a few different experiments including the observation of the Asian clams at different concentrations of EarthTec. The purpose of this report and study was to find the optimal amount of EarthTec to use for the greatest percent of mortality of Asian clams while maintaining a safe concentration of copper.

Schedule

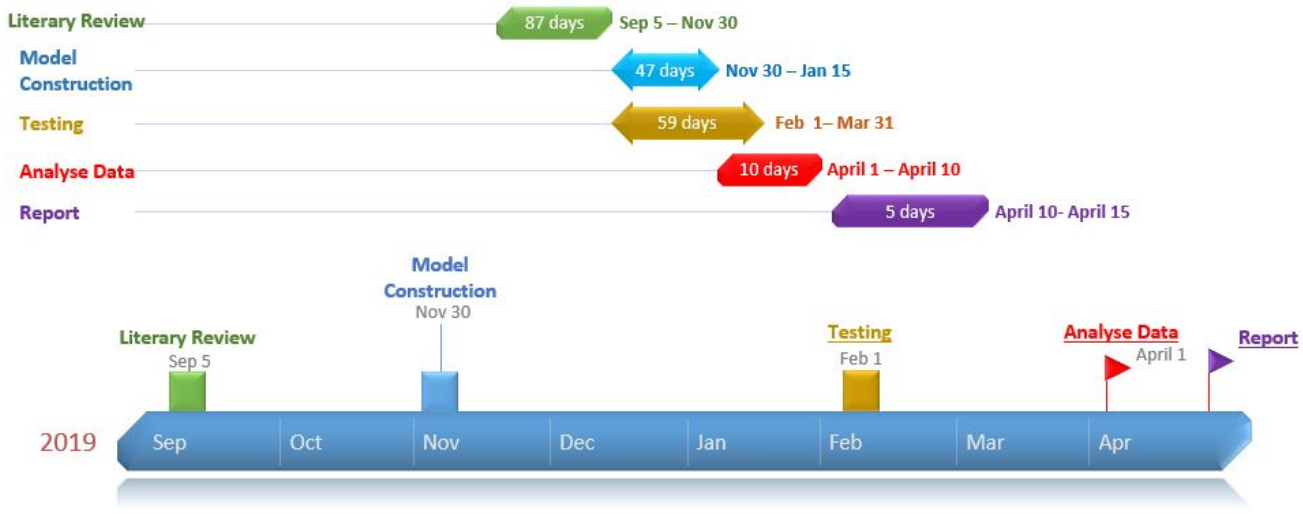

Figure 1 Schedule

The Project was divided into four milestones in order to make the project more productive. The first milestone was to do the literary review, in order to gather more information about Asian clams, and how this organism works under different circumstances. This step was crucial because clams are organism that tend to behave similarly to different circumstances. For example, under different concentrations of treatment chemical the difference between dead and live clams was unnoticeable.

The next step, which was planned to last 30 days, was the model construction which involved the construction of two black tanks in which the treatment chemical was poured. The initial design had a piece of wood on the middle of each tank in order to separate the tanks into two spaces. However, water pressure was breaking the wood piece in each tank. In addition, the caulk sealer was used to join the wood with the tanks, but water was leaking where the wood and the tanks join. These two problems caused the tanks construction to take more time than needed.

The third milestone was testing the treatment chemical. This milestone took almost two months. The first month clams were just put into the treatment tanks, and the corresponding results were recorded. Unfortunately, it was difficult to be certain that the observed clams were alive or dead. Thus, during the second month of testing, two fish tanks were used as pre-treatment and post-treatment observations. This allowed for a better understanding and more accurate measurement of the mortality rate of clams before and after treatment.

Finally, data was analysed by sending all the water samples for each testing to a laboratory in order to know the copper concentration in each test. The report was made using the results of these analyses.

Assumptions & Limitations

The proposed project counts with limitations and assumptions. The assumptions help to simplify the view of the problem, but overall the limitation and assumptions will have a high impact on the future results of the project.

Perhaps the most significant limitation was a lack of knowledge about the biology of the clams. The team spent a significant amount of time observing and studying how to tell whether clams were alive or dead. Different and often conflicting guidance was given by the client in regards to behavior and mortality of clams.

Another important limitation of the project is that it is quasi impossible to completely eradicate the Asian clams in the pressurized irrigation system since it could not be turned off. Many treatments have been proposed over the years, but none has shown total effectivity over the clam population. The goal was to evaluate the effectiveness of earth tec in controlling the population of clams.

Time constraints were also limitations. Each experiment lasted only 24 hours. It is assumed that 24 hours of treatment is enough for clams to feel the full effects of the chemical.

Another assumption made is that the testing environment inside the laboratory can simulate the real conditions such as flow, and chemical residuals. The BYU capstone team will assume that the flow will be steady in the open water sources such as open reservoirs. It will also assume the chemical residuals will last long enough in the open water resources even though water is leaving the system.

Another assumption made is that each clam sample is at about the same level of health as long as they were moving in the pre-test recording. This was not necessarily the case since some of the clams were stored for different amount of time before testing.

Design, Analysis & Results

Design

In this section the design of the experiment will be explained in detail. The general idea of the design is to determine the right amount of EarthTec that will have the greatest mortality while maintaining the restrictions set by EPA for the amount of copper in a system.

The materials that were used in this experiment were as follows:

- Two 100 gallon tubs
- Two 10 gallon glass fish tanks
- Two phones with time-lapse capabilities
- Two tripods
- EarthTec
- Measuring equipment
- Sand
- Fish net
- Two submersible pumps.

Before the experiments started, calculations were made to determine the amount of EarthTec that will be used in the system. To estimated the amount of EarthTec, we started by scaling down 1-2 gallons of EarthTec in one million gallons of water to the amount of EarthTec that will be needed in the 100 gallon tubs that will match the concentration suggested by the salesmen. This was done by using a proportion equation. We started with a low concentration of EarthTec and as the experiment proceeded, we gradually scaled up the concentration.

After the calculations were made, the experiment began. The first step of the experiment was to obtain clams from the City of Lehi. The way the City of Lehi obtained the clams was by opening a water hydrant and collecting the clams after some were flushed out. The problem with this was that because the clams were coming out at high velocities and pressure, some of the clams were cracked. This could mean that some of the clams may have died due to impact, making it difficult to determine the effectiveness of EarthTec. To eliminated this variable, we started by selecting the clams that were not cracked and seemed to be closed and in a good condition. For each experiment about 30 - 40 clams were selected; from the clams that were selected they were placed into a 10 gallon fish tank that had approximately 4 inches of sand throughout the bottom. The clams were lined up in a linear row facing the front. With a phone being held up by a tripod pointing towards the clams, the clams were recorded for a period of 24 hours.

After the clams were observed for 24 hours, the footage of the video was analyzed to see which clams had the most movement. In a spreadsheet, the discoved data was recorded. The next step was placing the clams in the 100 gallon tubs with the concentration of EarthTec that was determined in an earlier step. From the clams that were recorded, they were evenly separated into two tubs with different EarthTec concentration. The tubs also contained a pump each, the pump

was to keep an adequate level of oxygen and to mix the earthTec that was added. The Clams were left in the treatment for a total of 24 hours.

The next step was to take the clams that were treated out and placed in the fish tanks. In addition samples of the treatment water was collected into water bottles, these water bottles were labeled with the date the experiment ended and the amount of EarthTec that was added. These samples were later taken to the BYU laboratory for testing of copper. The clams were placed in a row as they were in earlier an step with the recording camera phone pointed towards the clams. The clams were then recorded for a total of 24 hours using a time-lapse. After 24 hours the clams were properly disposed of and the footage was analysed to determine which clams had no moment. The clams that had no movement were considered dead. In the figure below, the steps mentioned in this description are mentioned in chronological order.

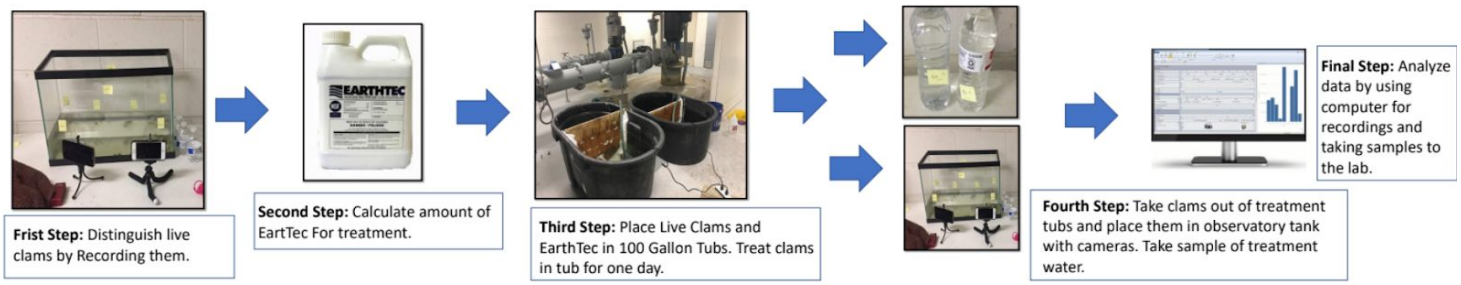

Figure 1. Steps Used for Experiment.

Figure 2. Treatment Tank

Figure 3. Observatory Fish Tanks

Analysis & Results

Form the data that was collected in the experiment mentioned above, the graph below shows the mortality percent vs copper concentration. From data that we collected, the most effective eradication of clams was using 8.81 gallons of EarthTec for 1 million gallons of water; this high concentration of earthTec was gave us a 89% mortality of clams. However, this is not feasible because of the high concentration of copper with that amount of EarthTec. In addition, the cost to treat million of gallons of water with high concentration will not be cost effective nor realistic.

In addition some factors that might have played a role in causing error in the data could be proper measurements of EarthTec; because the amount of earthTec was so small sometimes it was difficult to measure the exact amount of EarthTec. Another factor that may have caused error in our experiment is that each 100 gallon tub could have had different amounts of water, thus the proportional equation that we used to calculated the amount of copper could have been incorrect.

Gallons of Earthtec Per 1 Million Gallons of Water	Cu ppm (mg/l)	Percent of Mortality
1.76	0.17	43%
3.52	0.19	49%
4.01	0.24	53%
4.11	0.25	56%
5.28	0.26	60%
5.87	0.3	66%
8.81	1.18	89%

Table 1 Experimental Data Summary

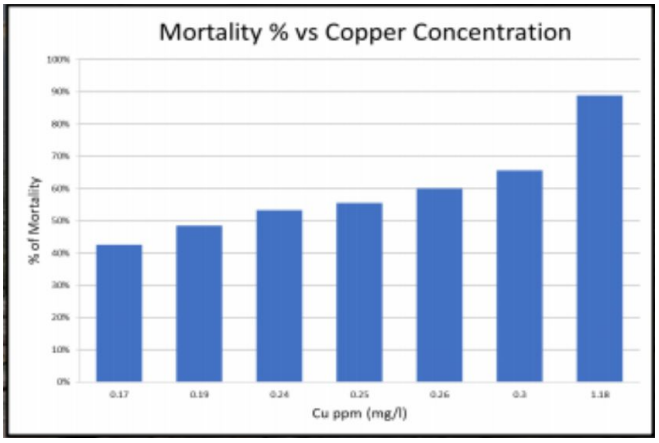

Figure 4 Mortality vs Copper Concentration.

Lessons Learned

While the capstone project did not go exactly expected, there were many lessons learned while working on this project.

There is a saying attributed to Albert Einstein stating: "If you can't explain something simply, then you do not understand it well enough." It is easier to design a complex model. Perhaps it is because as the engineers we are not directly the ones constructing what we have designed. However, when a model needs to be physically built, it needs to be realistic. Also, the amount of details in the design should be proportional to the importance of that part of the project. We shouldn't have gone so deeply into the details when designing the tanks.

Also, preparation is extremely important. The experiments ran a lot smoother when team members devised a plan and a wrote a procedure before going into it. In addition, proper preparation helps with better organization. It is much easier to analyze the results when the team understands and the data is well organized.

Lastly, this project allowed us to think outside the box. Generally, engineering problems encountered in classes have a few methods that work and that method generates a single solution or a limited set of solutions. Students are taught a specific method and thus get a limited set of answers. In real life applications, there are more than one solution, and more than one way to get there. This project allowed us to figure out a method that works and come up with a conclusion.

Conclusions

The BYU capstone team have concluded that while EarthTec is effective, the claims made earlier understated the concentration of earthTec necessary and it is not feasible to completely eradicate the population of clams. It is possible however to control it and we suggest using 2-4 gallons of earthtec for one million gallons of water to get to an 50-60% mortality rate. Also we recommend periodic checks of the amount of residual copper in the system to stay below the restrictions set by the EPA.

Recommendations

Based on our studies and research. We have come to the conclusion with the recommendation of putting 2-4 gallons of EarthTec for every million gallon of water. According to our data this concentration will give us .18 - .24 ppm of copper. The claims made have been overstated, EarthTec's concentration is not as strong as advertised. In reality there will needs to be more purchases of EarthTec to provide the desirable copper sulfide concentration to control the clam population found in Lehi.

For more effective mortality rates among the clam population, dosages have to be continuously added after initial treatment It is best to first put the highest concentration allowed and continue to put a much lower dosage of chemicals for continuation of the treatment period. By including chloride treatment alongside EarthTec, the mortality rate can be high and the clam population size can be easily managed

The behavior of clams are very indeterminate, further research of this species need to continue. Available information about the Asian clams are limited. Meanwhile the zebra mussel is a more studied species while sharing a common bivalve respiratory system. Due to the lack of research material pertaining Asian clam and anything pertaining to the *Corbicula* family, it is suggested to study zebra mussel and quagga mussels to further understand Asian clams.

There is a need to continue figuring out what constitutes a living clam from a dead one. A need to find what can make clams dead or at the very least, be treated like dead in order to clear Lehi's pipes more efficiently. The more information about these species can be a closer step to resolving a common issue among hundreds of place in the US resulting in billions of dollars due to maintenance and repair.

Appendix A

Memorandum From Hansen Allen and Luce. This Memorandum was made for the city of Lehi to control the population of clams. In this Memorandum there are different suggestions to control the population.

HANSEN ALLEN & LUCE inc
ENGINEERS

MEMORANDUM

DATE: April 05, 2017

TO: Dave Norman, P.E.
Water Systems Director
Lehi City
2538 North 300 West
Lehi, UT 84043

FROM: Ryan Christensen, Ph.D., P.E.
Hansen, Allen & Luce, Inc. (HAL)
6771 South 900 East
Midvale, Utah 84047

PROFESSIONAL ENGINEER
04/05/2017
No. 8207014-2202
RYAN T.
CHRISTENSEN
STATE OF UTAH

SUBJECT: Recommended Asian Clam Prevention Plan

PROJECT NO.: 365.04.100

Report done by Wood Miller, PhD on Asian Clams or *Corbicula fluminea*

Report on Asian clam or *Corbicula fluminea*

Wood Miller, PhD

I have found and read some 50 technical journal articles about Asian clams or *Corbicula fluminea* (Muller, 1774), or at least it seems like 50 articles. In this report, I use Asian clam and *Corbicula fluminea* interchangeably. There was obviously a lot of overlap and repetition among the articles, so I tried to pick out and report the unique contributions from each article, and I only selected a few of the articles. Unfortunately, I was unable to find, and I don't think there exists at this time, a method, without negative consequences, for complete eradication of Asian clams, with the possible exception of Virkon (see article #5). Therefore, the most effective management methods consist of prevention, control, and containment.

Excerpts from technical journal article #1: