Reclaimed Wastewater and its Benefits When Used to Make Compost

Alicia Salmeron

Cal State Dominquez Hills

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Author Note

Alicia Salmeron, the Department of Interdisciplinary Studies in Environmental Studies

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Any questions regarding this article should be addressed to Alicia Salmeron, The Department of Interdisciplinary Studies in Environmental Studies, Cal State Dominguez Hills, Carson, California, 90747

Contact: ASalmeron4@toromail.csudh.edu

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Executive Summary

In many semi-arid regions reclaimed wastewater (RWW), has now become a reliable source of water for irrigation. This is due to the high demand for potable water (PW). With the climate changing and massive population growth in these regions, finding ways to utilize RWW for more than just irrigation is needed. This paper explains how RWW was used to make compost in order to help eliminate waste and utilize RWW instead of PW. Compost helps the agriculture industry use less fertilizers, improves their crop production and helpes rebuild the nutrient level in their soil. In this study several different types of composting materials where used along with RWW, PW, and an effective micro-inoculant, known as Em-1, to see the effects each one had on the soil. Over the course of six months the compost was made and applied to the composting site where the soils nutrient level was low and the salinity was high. The only irrigation the site had was rainwater. Very few plants grew there and what did grow where salt tolerant weeds. Once the compost was applied it was watered once a week for three weeks with either RWW or PW. After the course of three weeks the soil was tested again. Although most of the nutrient levels stayed the same the potassium and salinity changed. These results proved that RWW can be used with compost, but only with food waste and not green waste.

Project Objective

Water is considered an inexhaustible resource; it is plentiful, and the earth is predominately made up of water. Why shouldn't people use as much water as they want? I am glad you asked, because unfortunately 97% of water on earth is ocean water and only 3% is in freshwater, and of that 3% that is freshwater, most of the water is locked away in ice caps and glaciers, (Dorsner, 2019, p. 237). This makes the fresh water, which is locked away, an unreliable resource. With the climate changing and the ice caps melting, one would think that this would make fresh water readily available to be used, but unfortunately this is not the case. The ice caps and glaciers are in areas that are remote and hard to get to, making this source of fresh water not accessible. Water is what makes this world great, but having access to it is what makes the developed world so different from everywhere else. There was a time when people thought that there would always be plenty of water to go around, but as the times change people are realizing how precious this resource truly is.

Fresh water is unevenly distributed causing some areas to have too much fresh water that to the point they have to release some of it back into the ocean. Other areas get little to no fresh water, leaving them no choice but to build water channels to transport the water from hundreds of miles away. This is not only costly, but dangerous to natural systems. By diverting water from one area to the next, it can cause significant effects to the natural systems that were once in place. Water which was once a free-flowing resource that is available to all, has now become a necessary resource that is only available for humans who have the domain over it. The amount that is needed to produce energy, food, and mineral resources, (Dorsner, 2019, p. 242), has put the demand so high that it no longer a plentiful resource in some areas.

The reason why I got into composting and reclaimed water was because I see how much water gets wasted every day in garden centers, at homes, on our street, at schools, and just about anywhere water is used. My ultimate goal is to be part of the solution right alongside The Natural Resources Conservation Service (NRCS) and The Agricultural Research Service (ARS), helping them find solutions to better manage our water and waste. My plan is to use reclaimed wastewater with the compost I make in order to find a healthy balance. In hopes that I can persuade more industries to invest in using reclaimed wastewater and compost to help eliminate the amount of waste that accumulates. Waste has become a part of everyday life, and to be able to utilize the waste in productive forms can help mitigate climate change and reduce our footprint.

The demand for fresh water is higher in metropolitan areas than in rural areas, and it is higher now than it has ever been, (Dorsner, 2019, 236). There are many reasons why this is true, but the one that is causing most damage, is the massive population that exist on earth. In order to feed this population, people are now growing more food than is actually needed. The amount of water that goes into growing food is exorbitant. Add that to a growing population, and one can see how the amount of water needed can add up quickly. Just growing one tomato can take three gallons of water, (Dorsner, 2019, p.242), and this is just one tomato. People consume more than they need making it almost impossible to not waste water, and this is just for growing food. Water is wasted in the mundane task that are done every day such as, when people take extra-long showers, or when they leave the sink running when they brush their teeth or shave their legs. Irrigation systems are put in place to conserve water, but unfortunately some sprinkler heads water the street instead. The list of wasteful water practices can go on and on, but I think the point has been made. I have found that utilizing reclaimed wastewater (RWW), can help alleviate this problem. By using RWW it can help reduce the amount of fresh water (FW) that is being used. RWW can be used for more than just irrigation, it can also be used to make compost. The process of making compost is water heavy, and by using RWW to make compost it ensures no valuable potable water gets wasted.

Working as a landscape professional I have seen the horrible things people have done to their yards. They neglect it, over water it, over fertilize it, over plant it, and wonder why things die so fast. Very few people stop to think about the soil biology and how this could help them establish a healthy yard, which in turn wastes little to no water helps reduce carbon emissions and can improve their air quality around them. Simply by adding compost and adequate amounts of water to the soil, it can help rebuild their soil and assist with combating climate change. Compost is a mixture of decomposed material that gets broken down into a state to which plants and the soil microorganisms can use it to fuel their growth. With healthy soil comes healthy plants, which in turn leads to less amounts of water wasted and less pollutants being sent back into the air.

There are so many ways to help reduce water, but because it is plentiful in some areas, people do not see the need to conserve, unless they are in a severe drought. Working at a nursery for over six years can change the way a person sees plants and people. The amount of water that goes into keeping a garden center open is absolutely terrifying. Plants need water to survive and if they are not watered properly they die, so all the water that was once used to keep the plant alive was used for nothing. Now, if a plant is alive long enough to find a home with a customer, then there is a chance that the water used to keep the plant a live was for good reason. That is if the customer can keep it alive once they planted it. The number one reason a plants die is due to overwatering. People think they need to overcompensate to get plants growing faster, but they are just killing the plant with excessive amounts of water and wasting a precious commodity. Plants and people need water to survive without water life cannot exist.

With everything that I have learned about compost and soil depletion, I have decided to take composting to a new level. I am incorporating EM into some of the compost I am making here on campus. My goal is to see if adding the EM to my compost, made with RWW, can improve the quality of the compost. Our university is predominantly irrigated with RWW and some of the landscapes are not allowed to be water, because they claim the RWW is destroying the landscape and soil. I would like to help make it so that the landscapes here on our campus thrive. I would also like to help reduce the amount of waste we accumulate on campus and incorporate that back into the campus, by turning it into compost that is made with RWW. In doing so our urban campus will become a leading example for other urban campuses, in helping them switch to better sustainable practices and reduce their waste on their campus as well. By being able to eliminate a good portion of our waste and by utilizing RWW we will be doing our part to help reduce our carbon footprint and make our campus that much more sustainable. My hope is that this research will lead into an area that will take composting to a whole new level. Composting is not just for farmers and businesses to profit from. It can be done in every city and in every country to help maintain waste and remediate soil.

Literature Review

What makes earth habitable is water. Without it, life cannot exist. With an ever growing population this is one resource that needs to be sustained, to ensure that there will be water for present and future generations, (Chen, Lu, Pan, Wang & Wu, 2015, p. 654; Khaliq, Al-Busaidi, Amed, Al-wardly, Agrama, & Choudri, 2017, p. 290). One-way water conservation has been established is by recycling water and turning it into what is known as reclaimed wastewater, (RWW). RWW is made from the discharge of domestic, industrial, sanitation, agriculture, water waste discharge, and water runoff. Which then gets sent to facilities that treat it and adjust the water so that the quality of it is suitable to be used again, (Ahmad, Bajahlan, & Al-Hajery, 2010, p.707; Furumi, 2008, p. 344; Zalacain, Martinez-Perez, Bienes, & Garcia-Diaz, 2019, p. 468). The United States alone can use up to 80% of its fresh water for agricultural usage, (Sheikl, Nelson, Haddad, & Thebo, 2018, p.28). Along with the agricultural use, mega cities are being built, and more industrial sites are being developed, and these all require large amounts of water and at a rate at which the fresh water cannot be replenished. Some areas simply cannot keep up with the demand, (Chen et al. 2015, p. 654).

The fact that RWW can be used as an alternative to fresh water, (FW), offers a solution to elevate the pressure of FW in areas where water is at high demand. Reusing water can help to reduce waste, recycle nutrients, reduce fresh water pollution, as well as help reduce coastal pollution. The increase of droughts in large parts of the world makes use of RWW unavoidable, (Bourazanis, Katsileros, Kosmas, & Kerkides, 2016, p. 2868). RWW has been able to alleviate water shortages, reduce the demand for FW, and reduce the usage of synthetic fertilizers in agricultural areas, (Lu, Wang, Pei, 2016, pg. 1). With the advances in water treatment facilities over the years it has now become a sustainable way to help reduce, reuse, and recycle wastewater, and in turn ameliorate the soil quality, (Lyu & Chen, 2016, p. 4639).

Not all RWW treatment facilities recycle their wastewater (WW) the same and this can lead to potential risks. This can cause environmental, human health and food supply issues, (Charlton, Sakrabani, Tyrell, Casado, McGrath, Crooks,…Campbell, 2016, p.1022; Furumi, 2008, p. 344). The agriculture industry uses a huge amount of RWW supply and if the WW is not treated properly it can create issues such as soil health, plant growth, and reduce food productivity. Some studies have shown that the use of RWW on soil can result in the accumulation of salts, it has been known to raise the soil's pH, and RWW can also be traced back to leaving harmful trace elements and metals, (Chen, et al. 2015, p. 660; Chen, Wu, Frankenberger Jr., & Chang, 2008, p. s-40). Even with all the benefits of using RWW, there is a negative stigma when it comes to using RWW, because it is not always treated or used properly.

Studies on RWW are now focused on the long term effects that RWW has on the soil whether good or bad. RWW can add nutrients to the soil which is beneficial to the soil's microorganisms and plant growth, but it can also reduce the soil's stability and led to soil deterioration, (Bourazanis, et al., 2016, p. 869; Lyu, et al., 2016, p. 4639). Researches are suggesting that RWW should only be used on a short term basis, they claim that as long as it is not used more than twenty-four months that there is no heavy metal accumulation, and if there is it is within the acceptable limits for agriculture use, (Lu, et al., 2016, p. 5). On the other side there are cities that have been using RWW for ten plus years and their research has shown that if managed properly the use of RWW, as a source of water for irrigation, can ameliorate the soil and in some cases they even found that the soil chemistry was close to that of a natural forest, (Lyu, et al., 2016, p. 4639). Studies have shown that the recycled form of nitrogen (N) and phosphorous (P) in RWW is readily available in a form in which plants can use, (Chen et al., 2015, p. 6611). With more research comes more reason why RWW is so beneficial.

Highly populated urban areas, such as Southern California, can make use of RWW much easier due to the fact that the RWW doesn't have to travel far, but it is not as economically efficient for some agricultural crops due to the distance it would have to travel, (Sheikh, et al., 2018, p. 30). RWW can help reduce the reliance on water that is imported and it can help big cities with their demand for water, (Chen, et al., 2015, p. 655, Chen, et al., 2008, p. S-40, &

Sheikh, et al., 2018, p. 38). Studies have also shown that RWW can restore water fronts and aquatic ecosystems, (Furumai, 2008, p. 344). Recent studies have also shown that RWW can help stimulate the microbial community that lives in the top few inches of soil, (Chen, et al., 2008, p. S-40). With proper management, proper maintenance, and setting limitations, the use of RWW can have great impacts, (Amad, Bajahlan, & Al-Hajery, 2010, p. 707, Charlton, et al., 2016, p. 1022, & Zalacain, Martinex-Perez, Bienes, Garcia-Diaz, & Sastre-Merlin, 2019, p.474).

New studies are being done to see what the effects of RWW has on compost. Through resent research it has been said that RWW, when used with compost, can help improve the soils structure, (Changanti, Crohn, & Simunek, 2015, p. 263). The purpose of composting is to provide a sustainable way to reduce waste and help remediate soil, (Aggelides & Londra, 2000, p. 253, Changanti, et al., 2015, p. 255, Charlton, et al., 2016, p. 1021, & Fei-Baffoe, Osei, Agyapon, & Nykankson, 2015, p. 27). Compost has been used for years to help plants develop deeper roots, maintain a healthy nutrient balance in the soil, reduce water runoff, (Aggelides, et al. 2000, p. 257, Charlton, et al., 2016, p.1022, Logsdon, Saver, & Shipitalo, 2017, p. 353, & Ortuno, Lorente, Hernandez, & Sanchez-Blanco, 2018, p. 306), and it has also been used to help remediate salt that has accumulated in the soil, (Chaganti, et al. 2015, p. 256). Salinity is one of the major threats to agricultural production and the ecosystems sustainability, (Setia, Setia, & Marschner, 2012, p. 475). Salinity can lead to plant deformities, reduce plant growth, cause crop death, and it can also lead to microbial depletion, (Chaganti, et al., 2015, p. 255, Charlton, et al. 2016, p. 1022, Rietz & Haynes, 2003, p. 846, Setia, et al., 2012, p. 475). The microbial community is what keeps the soil healthy, balanced, and functioning properly, (Rietz, et al., 2003, p. 846).

Compost can be used as a soil amendment to help stimulate the microbial organisms, but when it is worked into the soil, the microbial community does get disturbed in the process. In the longer term it helps to rebuild the microbial environment, it also allows for deeper plant roots, it helps by creating less water runoff, and helps with soil erosion (Logsdon, et al. 2017, p. 353). Compost is made up of decomposed material that continually decomposes, which will become depleted over time. Since most soils have become depleted of its nutrients, by reapplying the compost the process of building the soil will continue, (Logsdon, et al., p 355). The depleted soil will continually need to be replenished if it is an agricultural crop, as for the landscape the soil will not be disturbed as much, so the reapplication will not be as frequent.

With all the research that is being done there is still much to learn. Reducing waste and utilizing it as it was intended to be is a start. Finding a way to maximize the benefits of RWW and compost is an area of research that has a lot more to learn. There is new research being done on effective microorganisms (EM) and the benefits they have on the soil and the ecosystem as a whole. EM has beneficial bacteria such as phototropic bacteria, lactic acid bacteria, and yeast, which have all been proven to be beneficial when remediating soil, (Shihab, 2010, p. 37). When the EM is used with organic matter it aids in rebuilding the soil and plants overall structure, (Shiab, 2010, p. 37).

Project Approach

The soil in Carson lacks all the nutrients needed to grow healthy self-sustainable plants. The goal of this project is to help rejuvenate the soil at California State Dominquez Hills (CSUDH), by using the green waste, food waste, and carbon sources that accumulated here on campus. The green waste that was collected came from the landscape material that campus Facilities Services accumulates on their rounds on a day to day basis. The food waste was from the kitchen on campus and also from a designated drop off composting bin located at the DH (Dominguez Hills) Urban Farm on campus, this includes uncooked fruits and vegetables. The carbon source came from some of the landscape, waste such as dried leaves, but most of it comes from shredded paper and shredded cardboard that was collected from the campus. The CSUDH landscape is predominately watered by using reclaimed wastewater (RWW), which is still very controversial. Claims have been made that state the use of RMM accumulates salts and other nutrients that is detrimental to all plants and soil. This is why research in this area is crucial to CSUDH. These composting methodologies were chosen in order to use both potable water and RWW in the compost.

The site selected is a location at CSUDH, which has been abandoned for years. The site is barren and lacks all nutrients needed to grow healthy vegetation. A section that was approximately 20’ x 20’ was fenced off, (fencing and steel bars were needed for the frame, due to the rabbits and coyotes that repeatedly destroyed the grid.) Each grid section was approximately 2’ x 2’, and it was separated into nine grids. Nine soil samples were extracted using an eight inch soil probe, and the samples were put into paper bags and allowed to air dry. Then they were sifted through a fine mesh screen to ensure all large particles were removed before the soil samples were tested. Each soil sample was tested for nitrogen, phosphorus, potassium, pH, and salinity.

The nine girds were needed to be able to utilize the eight different types of compost that was made over the course of five months and to have a control. The compost was made in eight self- contained composting bins designated with a number that coordinated the materials that was used in each bin (Table 1). Four compost bins contained food waste, two using potable water and two using RWW. One food waste/potable water and one food waste/ RWW was given a microbial inoculant that was added to the composting bins as needed. Four composting bins contained green waste, two using potable water and two using RWW. One green waste/ potable water and one green waste/ RWW was also given a microbial inoculant as needed. The amount and type of composting material and water added to each bin was measured and recorded along with the turning of the piles.

Table 1: Number designates eight self-contained composting bins coordinated to materials used and section of soil amended with number nine being the control section.

Bin and Section Number	**Source Material**	**Source Water**	**Inoculant**
1	Green Waste	Potable	None
2	Green Waste	Potable	EM-1 Activator
3	Green Waste	Reclaimed	None
4	Green Waste	Reclaimed	EM-1 Activator
5	Food Waste	Potable	None
6	Food Waste	Potable	EM-1 Activator
7	Food Waste	Reclaimed	None
8	Food Waste	Reclaimed	EM-1 Activator
9	None	None	None

Surveys were sent to select composting companies to see if they use RWW in the process of making their compost. The surveys were sent out with only four questions to ensure more responses. This method of collecting data was chosen to ensure a quick response time and to see if people are willing to use the RWW. No data was found with regards to who uses RWW in the process of making their compost. Each survey would allow me to see if people were still reluctant to using RWW or if the stigma has changed due to the demand of FW.

Each compost bin was given five months to decompose. In the first four months of composting each bin was turned twice a week. In the fifth month the composting bins were turned twice a day. After the five month mark each compost was sifted through a screen to ensure that only decomposed material was used. The compost was then applied to its corresponding section of the grid. The compost was tested to see what nutrients were available. After application each section was watered with the corresponding water source, this was to ensure that the compost would begin to penetrate the top layer of the soil. Since the area is dry and arid it had to be watered twice a week. After three weeks new soil samples were taken with the same eight inch soil probe. Each sample was air dried and sifted once again to remove all large particles. All samples were tested for nitrogen, phosphorus, potassium, pH, and salinity. Once all the results were collected it was put into a graph in order to compare the results.

Project Outcomes

When the soil was first tested before the compost application, I found that there was no nitrate in the soil, it had no potassium, the phosphorous was on the medium to high scale, the pH was basic, and the salinity was all over the place. This was of no surprise due to the fact that this area has been abandoned for years, it has no canopy coverage and only a small amount of vegetation. During the late winter and early spring of 2019 heavy rain hit Southern California and this allowed lots of vegetation to grow, but all the vegetation was in the form of weeds. Now that there was lots of coverage I had hoped that it would help keep my compost moist so that once it was applied it would not dry out to quickly.

I also sent out a few surveys to see if some of the composting companies would be interested in using RWW in the process of making compost and to my surprise more people were willing to use it than not. Some companies already used it and it was their only source of water for making compost. Others would love to use it, but unfortunately the cost of getting the pipeline to them is not within their budget. Some have no need for it due to the fact that they have heavy rain fall. There were a few that would not use it, claiming that it is because they are an organic composting farm the use of RWW does not fit their requirements to keep their compost organic. The goal of compost is to utilize waste, not to create more products that generate more greenhouse gases and more waste.

The compost that I made was from material found on campus and through local landscaping companies. The compost was started in December 2018 and was close to completion in April 2019. Through this process I found that the compost that was made with RWW did not decompose the carbon material thoroughly. There were nitrogen balls that accumulated in the compost, making it impossible for the compost to decompose properly. I believe this is the result of consistent turning of the compost bins and from the lack of moisture in the composter. Without proper moisture compost cannot decompose properly and evenly.

On April 6, 2019 the compost was applied to the soil in the selected location that was designated for that compost. Since the weeds in this area became over grown, due to the heavy rain, a small area was cleared away before applying the compost. Two gallons of the corresponding water was applied to the compost once when the compost was applied and then again later that week, to ensure the compost had adequate moisture. On April 27, 2019, new soil samples were taken in order to compare them with soil samples taken in early January 2019. I found that the pH, nitrate, and phosphorous did not change even with the compost application. However, the salinity and potassium did change, (See figures 1 and 2). In some of the plots there was only a slight difference, but in others it was completely different.

I found that although RWW does add some additional salt to the soil, the compost made with RWW and food waste helped to balance the potassium in the soil. With a balanced potassium and salinity ratio the salinity level in the soil can be lowered allowing for less salinity build up, (Kader, A, & Lindberg, S., 2005, 3149). I found that the Em-1 did make a difference when making the compost. The compost helped add potassium to the soil to help balance out the salt that had accumulated in the soil and it did not matter if it was made with RWW or PW. Although RWW did have a high salinity reading compared to the PW once it was applied to the compost the added nutrients helped balance the salinity.

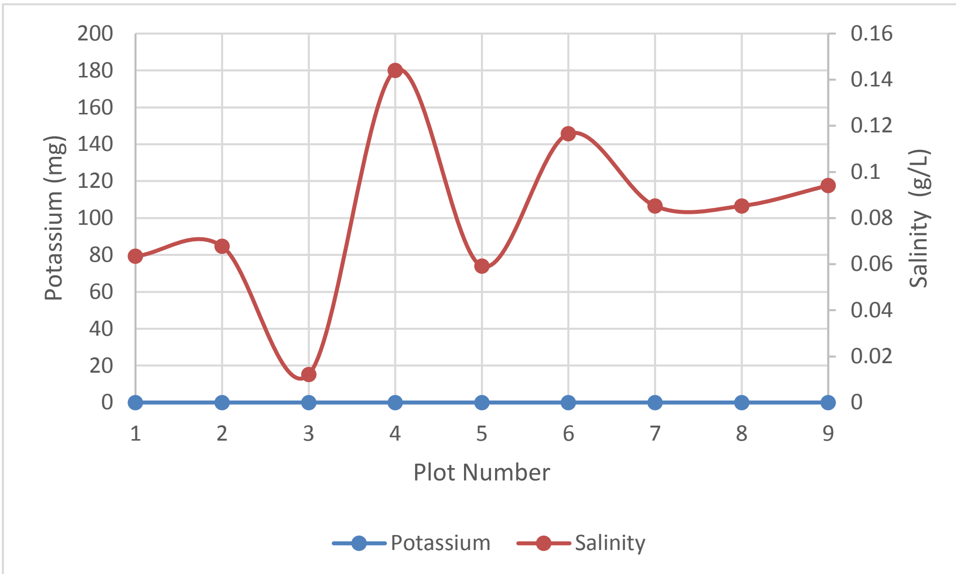

Figure 1. Soil sample test results pre-compost with number 9 being the control.

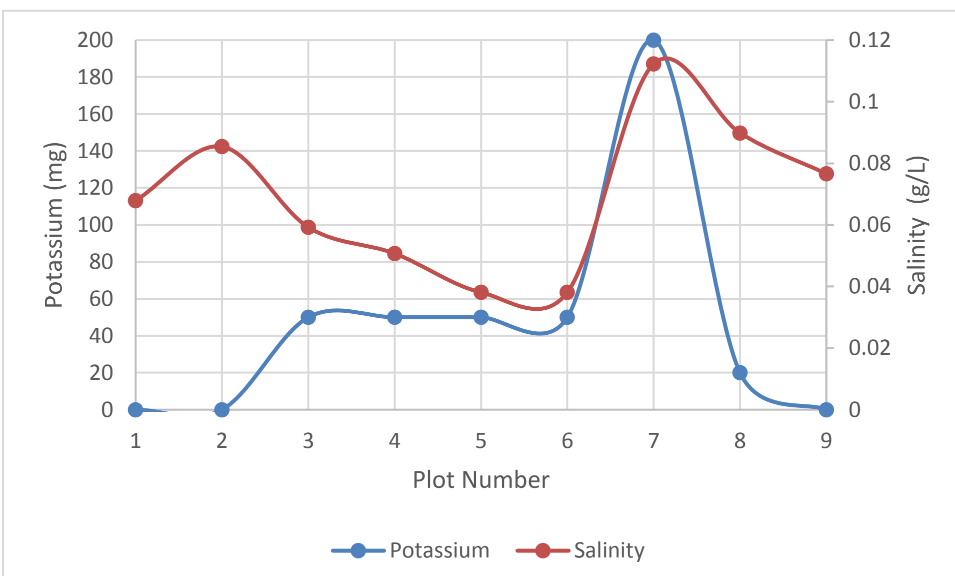

Figure 2. Soil sample test results post-compost with plot 9 being the control.

Discussion

The amount of fresh water that is needed to keep life going is increasing and with the population increasing people are looking for alternative methods to keep up with the demand, (Njuguna, S. M., Makokha, V. A., Yan, X., Gituru, R. W., Wang, Q., & Wang, J., 2019, 576). Harvesting reclaimed wastewater has been an alternative water source for years now and when it is properly managed it can have positive impacts on the areas that have been irrigated with RWW, (Ahmad et al. 2010, 707). If the soil is watered improperly with RWW it can have negative effects on the soil, (Lyu, & Chen, 2016, 4639). The CSUDH campus is in a drought-prone region of Los Angeles making it the perfect candidate for my research. The CSUDH campus has about 13% tree canopy coverage and the area that was designated for my grid did not have any of this coverage. The location I choose for my gird is windy, hot and dry. The soil is compacted to the point that I had to use a mallet, a soil probe, and my husband in order to retrieve my soil samples. The lack of nutrients and moisture created the perfect environment to do my testing. I needed an area that was not going to be effected by students or irrigation. This site allowed me to have full control of my samples. The amount of water that went into the plots and compost made a noticeable difference and I was able to see that the RWW was indeed beneficial to the soil.

In order to get a sense of the salinity that was in the RWW, I needed to measure the conductivity of the RWW that is used at CSUDH. To do so I collected a sample from my school and by measuring it I was able to use that for my comparison. CSUDH's RWW conductivity measured at 2.54 mg/cm at 68.8 °F. I had three weeks to allow the compost to penetrate the top layer of the soil and that made a difference. In order to compare the change in conductivity I had to take new samples. With the new samples I made a water solution, in order to test them properly. I let the samples sit in the water over night to ensure the water solution had a mixture of soil and water. I noticed with the addition of the compost to the soil the conductivity level dropped. The average of the new soil samples was 0.14 mg/cm at 67.1°F compared to the original samples which were 0.22 mg/cm. This is a significant difference in just three weeks' time. Once I converted the conductivity to salinity, I could see that by adding different forms of organic waste to the compost and using RWW the salinity levels could be reduced.

Since water quality plays a huge role at CSUDH, I could now see that RWW could be used to irrigate the plants on campus. All it would take is a thick layer of organic compost on the surface of the soil before the irrigation took place. CSUDH is predominantly irrigated with RWW, which is why measurements were needed in order to see if the compost lowered the salinity. Soil is the foundation to all life here on earth, (Dorsner, 2019, 172). Without proper soil health cities cannot be build, plants cannot grow, air would be unbreathable, and temperatures would be completely unbearable, (Dorsner, 2019, 173). In the city of Carson in California, where this research took place, the temperatures in the summer months can get into triple digits. The air is polluted due to Carson being an industrial city, and because it has several oil refineries within the city's borders. This is exactly why studies need to be done in order to find new innovative ways to rebuild soil, help eliminate waste, and purify the air. This can all be accomplished by simply rebuilding the soil and adding more vegetation to the landscape.

Compost has been used to help rebuild soil and reduce waste for decades. Compost in itself is a soil conditioner and an organic fertilizer, (Al-Madbouh, S., Al-Khatib, I. A., Al-Sari, M. I., Salahat, J. I., Jararaa, B. Y. A., & Ribbe, L., 2019, 209), that is made from recycled waste. Since not all compost is made from RWW, my idea for this experiment is to see if there is actually a difference between using RWW and FW when making the compost. Since the salinity in the RWW at CSUDH is high, I thought by using an Em-1 inoculant this would help rebuild the compost's nutrient content and help reduce the amount of salinity that would normally accumulate in the compost. In the four plots that received Em-1 there was a noticeable difference, but not in the scale I had hoped. Although it did change the salinity content slightly it did not change it enough to where it would make a difference in the soil's biology; at least not in the time I had allotted for this project. For a small-scale project and individual yards EM-1 is an ideal inoculant to help rebuild the soil. Em-1 is a very expensive additive and for me to not get the results I had hoped for I do not see it as an economically beneficial tool to help rebuild the soil on a large scale

In some of the research I read while doing this project I realized that most of the research was done on a short time scale and there was not much research on the long-term scale. One of the projects I found that was on the long-term scale was done in Beijing, by Chen et al., and their results showed that the longer the RWW was used the better the soil quality became. They noticed that there was some accumulation of salinity and heavy metals, but the numbers were low enough that is was insignificant, (Chen et al. 2015, 660). RWW can improve the soil quality but it will not happen in the short term. To see a significant improvement the RWW must be used for several years and in the proper amounts. The amount of water needed for each plant depends on the soil and the plant itself. The longer RWW is used both the nutrient level and biological activity in the soil will improve, (Chen et al. 2015, 661). Although my project only had three weeks to change the soil, significant changes were noticed. The potassium level changed in all but two plots and the salinity changed in all plots. In the beginning of my research I did not realize how crucial of a role potassium played in the soil's biology. By having a high potassium to sodium ration this can help balance the salinity that accumulates in the soil, (Shirazi, Ashraf, Khan, & Naqvi, 2005, 236). When the potassium levels are high it can help balance out the salinity levels, which can help reduce the amount of salt taken up by the plants.

While making the compost I noticed that the RWW did not decompose carbon very well. Carbon in the form of paper and cardboard broke down in the compost pile relatively fast, but carbon in the form of dried leaves did not decompose in RWW at all. When I sifted out the large pieces of debris from the compost I noticed that the leaves were completely intact, yet the leaves in FW compost broke down in a timely manner. With more time to allow my compost to decompose the leaves would have eventually decomposed in the RWW. The compost bin with RWW, Em-1 and green waste did give me great results even with the leaves not decomposing. The potassium in plot 7 rose from 0 to 200 mg and the salinity rose from .21 to .27mg/cm. The compost itself may not have broken down the leaves, but it did act as a mulch barrier and helped suppress the weeds and retain moisture. Although the salinity did rise by .5 mg/cm the potassium rose by 200% allowing for this increase of salinity. With higher salinity in the soil there must be a higher level of potassium to counterbalance the salinity, (Shirazi et al., 2005, 233).

The biggest complaint some of the departments have on campus is that the RWW is destroying the plant life on our campus, due to the salinity that has built up over time. In the research that I have read through, in the course of this project, I realize their biggest mistake is planting plants that are not salt tolerant. Also contributing is the fact that the plants in question get watered so seldom allowing for salt to accumulate in the soil. In order for the salt to be pushed out of the root zone it needs to be flushed out, and the only way this will happen is with regular watering cycles. Since my campus is predominantly drought tolerant and native plants some areas see very little water and in which case the salt accumulates in the top layer of the soil.

These plants are not used to the salinity in the soil and the water. This is where my compost comes in. Since our campus is trying to become a more sustainable landscape, they need to start with rebuilding their soil and setting up a watering schedule that is beneficial to the plants. The grass on our campus, in most areas, is nice and green and well taken care of. Since the grass is properly cared for and watered every week with enough water it helps flush out the unwanted salts. Without proper watering schedules the plants have no chance to survive on my campus.

One of the biggest obstacles I came across was the nitrogen balls. The compost had perfectly round balls from 1” to 5” in every bin. I do believe this is due to the fact that I had help when it came to turning my compost bins. I was unable to get to the campus every day, so I solicited help from my fellow interns, and each of us turned my composters twice a day for four weeks. I asked them to turn each bin ten times twice a day. They were supposed to spin the composter until they heard a drop, which was the compost shifting, and make a complete turn all the way around ensuring they heard it drop with each turn. What I think they did was spin it fast just to get their spins in. Proper spinning is crucial to helping the compost decompose properly and effectively. I ended up breaking the nitrogen balls up so they would spread evenly on to the surface of the soil. Unfortunately there was still no nitrate to be found in the soil before or after the compost application. I think this is because the nitrogen was fixed into balls, which prevented it from decomposing. Since the nitrogen did not decompose it was not in a state in which is available to be absorbed into the soil.

The compost itself was the hardest part to make. Due to the schedule the maintenance workers had to follow I was not able to collect the necessary nitrogen source for the green waste on campus. I had to outsource this from a local gardener. Unfortunately, I do not know if it had pesticides or herbicides in it which could have resulted in the Em-1 not being as effective as I had hoped for. I was unable to come up with the funding for the compost bins in a timely manner, so I had to start the compost a little later than I had originally wanted to. Once I got the funding for the composters, I had to wait for them to be delivered and then they came with missing pieces. Which was another setback since I had to wait for missing pieces to come in. My goal was to start the compost in August of 2018, but it did not get started till December 2018. For compost to decompose properly time and heat is needed and I did not have either of those. In late winter and early spring 2019 Southern California got a much-needed rainstorm. Although the rain was needed it set back by composting another month.

Limitations

There were several limitations I ran into while doing this project. The first one is the fact that I was unable to give this project the proper attention it deserved due to logistical delays (as mentioned above) and I had to rush my end results. I was unable to complete my project in a timely manner do to the fact that I was only able to get to campus two times a week and was heavily reliant on volunteers to help with the process. This made it impossible for me to ensure the compost stayed moist. In order for the compost to decompose properly and work its way into the soil moisture is needed. When it came to making time to start the compost, I had to wait to get the proper amounts of material. I wanted to start all the compost at the same time, but I was unable to. This was either because I did not have the material, or I ran out of the material and had to wait for the next time the material was dropped off. One of the funniest limitations I came across were bunnies. There are hundreds of bunnies that roam the campus at night and they kept destroying my grid. In order to keep the gird in tacked and to ensure the samples were not tampered with I had to put up a fence to keep the bunnies out. Once I had all the materials and got the bunny proof fence up, I was finally able to get to work. Having a team of interns to help assist me with my time sensitive project allowed me to execute this project in such a short amount of time.

Conclusion

Water can either give life or it can take life. One simply cannot exist without it. Finding alternative ways to utilize RWW can elevate some of the demand for fresh water and it can help restore depleted soil. RWW has changed over the past few decades and it is now something people are researching more in order to find new innovative ways to use it. Although not all RWW treatment plants are the same, their main goal is to make RWW safe so that it can be used again. RWW does have a higher than normal salinity level compared to FW, but as one can see through my research it can be altered within a few weeks. By using the RWW in the compost I was able to lower the salinity in some areas making the soil less problematic for plants.

The amount of water that is needed to keep CSUDH green and the students hydrated is on a steady incline. With the steady incline of students and the expansion of the landscapes comes an increase in green waste, food waste, and water. Being able to utilize all three of these resources and keeping them on campus will allow the campus to do its part to help combat climate change. Reducing the amount of waste that must be sent to the landfill is a small step, but it can have a huge impact on remediating the campuses soil and reducing their carbon footprint. By making the compost on campus this can change the way people view RWW and waste.

Even with the research I have done, I can see that there is still more research that is needed. The salinity levels are still too high in the RWW and barren soil is no place for salt heavy water nor is it a place for most plants. Remediating barren soil is not easy and remediating an entire campuses soil is unheard of. With more research and a better understanding of what is needed to remediate the soil, one can begin to find ways to utilize waste, compost, and RWW properly. With the compost I made I was able to utilize the RWW and help re-build a small portion of the campuses soil. Since this project was done on such a small scale more research is needed to see what needs to be done in order to remediate a larger and deeper portion of the soil on campus.

Even with all the limitations stacked against me I was still able to show proof that the salinity in the RWW can be altered with proper nutrients and irrigation. Soils need to be properly watered in order to have a healthy foundation for the future. One thing I noticed at CSUDH is that the RWW is not the main problem, it is the soil. The soil has been barren for years. Nothing has really been done to improve the soil itself. The plant selection for the campuses is changing, but unfortunately not in the direction it should be. Since the campus is predominantly watered with RWW the plant selection needs to be chosen accordingly and the plants that are selected need to be salt tolerant. Once the soil has been remediated then the campus can plant what ever they want, but until then the plant selection needs to be a focal point. RWW is here to stay and it is going to help sustain the massive population that is on earth. Without RWW landscapes would die, less food would be in the markets, water prices would go up, and people would die from dehydration. It is time to think about the future and how people can adapt to this ever changing climate.

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