CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Aleena R. Ali

Project Number
S1001

Project Title
Reduction of Nitrate in Ground and Drinking Water by Photocatalysis

Abstract

Objectives/Goals
The goal of this project was to effectively measure the concentrations of nitrate found in ground and drinking water and to use a commercially available titanium dioxide photocatalyst called P25 to reduce the concentration of nitrate.

Methods/Materials
1)Agilent HP 1100 Series HPLC DAD System Diode Array Detector with Dell Desktop Computer
2)Agilent ZORBAX StableBond C18 HPLC Column
3)UV Lamp
4)Sodium Nitrate (NaNO3)
5)Octylamine
6)Titanium Dioxide Photocatalysts (P25)
7)A variety of Water Samples

Results
P25 paired with a UV light source can effectively reduce the concentrations on nitrate found in water.

Summary Statement
Using titanium dioxide photocatalysts and a UV lamp light source, the concentrations of nitrate found in water can be reduced.

Help Received
Used lab equipment at Thousand Oaks High School under supervision of Dr. Malhotra; received materials from CLU's Dr. Quinlan; received tremendous amounts of information and knowledge from Dr. Cauchon

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Talia Arauzo; Jennifer Lee; Emily Zhang

Project Number

S1002

Project Title

Improving Recycling Methods through the Usage of Robotic Devices

Abstract

Objectives/Goals

The objective is to design and build a robot that can sort recyclable objects according to their composition, so that the recycling process may be carried out with more accuracy and celerity.

Methods/Materials

Our team first designed multiple versions of our robot layout, all of the preliminary designs and the final prototype sort through plastic, glass, tin, and aluminum bottles/cans using a hall sensor, voltage sensor, a simple weight test, servos, arduinos, magnets, and wires. Many tests were carried out in order for us to develop the most efficient, consistent, and swift robot.

Results

Our working prototype successfully sorted plastic, glass, tin, and aluminum into their respective compartments. The first test distinguished between metal and non-metal. Non-metals would slide down a vertical pipe for a simple weight test to distinguish between glass and plastic. The metals would continue sliding down the horizontal pipe for a magnetic test, utilizing a hall sensor, to distinguish between tin and aluminum objects.

Conclusions/Discussion

We were able to successfully build a robot that could compartmentalize different recyclable materials. With the integration of our contraption into society, the recycling process could be greatly expedited, especially in buildings with a lot of foot traffic.

Summary Statement

Our project designed and built a robot using servos, various sensors, and PVC pipes that could sort different recyclable objects in order to expedite and improve the recycling process.

Help Received

Our advisor, Mark Wong, gave advice and helped on preliminary designs and to attach servos to robot. Ace Hardware provided donations to buy materials and supplies. Talia's father aided us in using powerful machinery.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Kaitlyn A. Arst

Project Number

S1003

Project Title

Using Starch and Biopolymer Aqueous Solutions to Reduce Soil Erosion

Abstract

Objectives/Goals

The purpose of this study was to determine whether Corn Starch, Wheat Starch and Potato Starch each mixed into a solution with biodegradable biopolymers Xanthan Gum and Beta-1,3/1,6 Glucan could be used to strengthen the soil to make it more erosion resistant than untreated soil. If so, which soil amendment solution is most effective in controlling soil erosion? This research is divided into two phases. Phase one is a rain simulation test. Phase two is a plant germination test.

Methods/Materials

Soil was divided into 4 containers. Corn starch (CBX), Wheat starch (WBX) and Potato starch (PBX) each mixed into 3 individual aqueous solutions with Beta-1,3/1,6 glucan, Xanthan Gum and distilled water were applied into the soil of its respective container. One container, as the control had no added amendments to the soil. 5,350 mL of water was applied every other day for 2 weeks onto each soil container. After each cycle of rain, runoff soil was collected from each container, sieved, dried and weighed. The soil content of nitrogen, phosphorous, potash, and pH balance levels were tested. After 2 weeks, 50 seeds of Pisum sativum var. macrocarpon were planted into each container to test soil quality.

Results

Soil treated with the wheat starch mixed with Beta-1,3/1,6-glucan and Xanthan gum solution was the most effective in controlling soil erosion with a 1.4 grams average soil run off. While the non-treated soil had the most soil run off with an average of 193 grams of soil seeping through. The control plant also had the lowest germination rate after 7 days with 0% growth while the wheat starch mixed with Beta-1,3/1,6-glucan and Xanthan gum had a germination growth rate of 42%. The pH balance tests of the soil ranged from 7.0 (neutral) to 7.5 alkaline. The N, P and K tests ranged from depleted to surplus.

Conclusions/Discussion

The results showed the wheat starch mixed with Beta-1,3/1,6-glucan and Xanthan gum Biopolymer treatment remained stable against soil erosion and indicated this amendment can be used as an eco-friendly alternative for effective treatment of soil erosion. CBX would be next alternative compared to PBX which would be the least effective due to higher amount of soil runoff and lowest seed germination when compared to the WBX and CBX. The soil control did not perform well when compared to the WBX, CBX and PBX soil amendments.

Summary Statement

In this study, a novel environmentally friendly soil treatment was developed, using starch and biopolymer aqueous solutions to reduce soil erosion.

Help Received

My parents helped with buying materials and guiding me with safety precautions

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Ayan Bandyopadhyay

Project Number

S1004

Project Title

A Novel Microbial Fuel Cell Using Cobalt (II) Biomineralization to Increase Power Density

Abstract

Objectives/Goals

Wastewater treatment plants consume a significant portion of the electricity produced in the U.S. Microbial fuel cells(MFC's) have been developed to mitigate this problem by producing electricity from the organic waste while breaking it down. However, these MFCs have low power output due to low reduction potential at the cathode. Biocathodes involving bacterial oxidation of ions provide a possible solution to this problem. The purpose of this experiment was to determine whether a novel cobalt biocathode would increase power density more than the previously developed manganese biocathode.

Methods/Materials

Shewanella oneidensis was used to oxidize organic material in the anode chamber and Leptothrix cholodnii was used in the biocathodes. Three types of MFCs were built. One used a manganese biocathode, and another used a cobalt biocathode. A control group with oxygen reduction at the cathode was used. Power output was measured for 30 seconds, the amount of time it took to stabilize. An Arduino micro was used to measure voltage.

Results

While the manganese biocathode increased power density by 267% with respect to the control group, the cobalt biocathode increased power density by 594% with respect to the control group.

Conclusions/Discussion

The cobalt biocathode resulted in a higher power density than both the control group and the manganese biocathode, but its effects can be further improved by increasing the rate of microbial cobalt oxidation. Another benefit of using the cobalt biocathode is that it will remove Cobalt(II), which is a carcinogen in industrial waste.

Summary Statement

The ability of a novel cobalt biocathode to increase power density while purifying wastewater in an MFC was tested

Help Received

Used equipment under the supervision of Dr. Khalaf and Dr. Ismail at Schmahl Science Workshops. Parents helped set up board.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Sidharth Bommakanti

Project Number
S1005

Project Title
Wellness Water: Implementation of a Dual-Filtration System to Clarify Domestic Water Sources in Rural Ccommunities

Abstract

Objectives/Goals
My main goal was to Implement a sustainable, low-cost dual-filtration system to clarify contaminated domestic water sources in rural communities.

Methods/Materials
I created a slow sand filter bed after getting permission from the Panchayat. Upon completion, I commenced wetland construction. I conducted focus groups to collect data from community members who represent the entire spectrum of socioeconomic backgrounds. I created a high school water quality curriculum to integrate into the existing curriculum. All water quality measurements in the field were conducted using the DR890 handheld water quality test kit. Colorimetric assays were used to reveal the presence of nutrients, turbidity levels, pH, and oxygen content. Initial design plans to create a 1250 m3 wetland containing Canna Indicus, knotweed, and other plants in order to remove nitrates and phosphates that are being created. These plants were chosen specifically after much research for their sustainability and ability to coexist without outcompeting one another. The selected plants will be working synergistically with other plants that will modify the redox conditions of the existing soil substrate to allow the wetland to polish water at higher rates. An education plan was to integrate water science and wetland functions into the existing curriculum.

Results
The sand filter bed created minor reductions in key contaminants. Pre and post test results indicate an increase in knowledge and understanding in topics related to water sanitation and environmental contaminants. Members of the community have successfully showed an interest in the program and have with my assistance created the Water Quality Committee. Partnerships have been established with the Panchayat, the CDD Society, Journeyman Internation Inc, and the Kowtaram High School.

Conclusions/Discussion
Pilot presentation of high school water sanitation curriculum received overwhelming support from the local government and high school administration. The dual filtration system is both a low cost and sustainable water purification method. Full length curriculum in Kowtaram's local high school will be taught in grades 9-12. Implementation of wetland system and monitoring of water quality after dual filtration is in place.

Summary Statement
My project is an attempt to find a way to clarify domestic water sources throughout the world

Help Received
Mrs. Pereira helped with supplies

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Chloe Breen; Jade Doyle

Project Number
S1006

Project Title
Biofermentation

Abstract

Objectives/Goals
My objective is to see if I can successfully convert goat manure and grape pomace into biofuel

Methods/Materials
grape pomace ,goat manure, 50 gallon empty drums, totes, pvc pipe

Results
goat manure will produce 2 gallons of methane each week.grape pomace will produce no gas until approximately 8 weeks after creation in which it will produce one gallon of carbon dioxide.

Conclusions/Discussion
experiment was successful

Summary Statement
My project is about successfully converting goat manure and grape pomace into renuable biofuel.

Help Received
Parter Jade helped brain storm to make project come to fruition. My step dad helped construct bio fermantater.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Roxanne Esparza; Andrea Uribe

Project Number

S1007

Project Title

Obtaining Energy from Trash

Abstract

Objectives/Goals

To obtain the most biogas possible from one of the following biomasses: grated carrots, cow manure, or a mashed banana, and then measure it.

Look for a way to impact the researchers' community in a positive way using the resources of said community. In this case it happened to be Kern County.

Methods/Materials

Some of the key materials in this experiment are, 360 grams of cow manure, grated carrots, and mashed banana, 9 (1) Liter bottles, distilled water, 9 latex balloons, a bucket or large bowl of water, and a beaker.

To obtain the biogas the biomasses were placed in a 1L bottle filled with distilled water and covered with a balloon. The gas trapped inside the balloon is the biogas released.

To measure the biogas trapped inside, the method of water displacement was used, a beaker filled with water was placed over a bucket of water, the tip of the balloon was carefully released under the beaker, the water it displaced was the amount of gas trapped inside the balloon.

Results

The mashed banana produced the least amount of biogas (.025L) with grated carrots at a close second at (.029L), and cow manure taking a big lead by producing (.053L).

Conclusions/Discussion

This experiment reveals that obtaining energy from trash really is possible, and that obtaining energy from trash by this method could help lead into a greener energy use. Although this experiment only helped obtain the biogas from each of the biomasses, this experiment leads to better and greater things. For example the creation of a methane digester that collects manure and other wastes. The methane digester could potentially turn the biogas acquired and turn it into methane. This method can be used to run household appliances. With this inventive and resourceful method the creation of biogas from the cow manure and other biomasses can benefit the environment drastically.

Summary Statement

To obtain the most biogas possible from one of the following biomasses: grated carrots, cow manure, or a mashed banana, and then measure it.

Help Received

Parent's helped acquire cow manure; Neighbor provided juicer to obtain grated carrots and a scale; Mr. Yoon and Mrs. Berry helped give back feedback.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Gabriela N. Goldberg

Project Number
S1008

Project Title
Fecal Matters: Generating Electricity with a Microbial Fuel Cell

Abstract

Objectives/Goals
The purpose of this project was to learn how using different types of wastewater in a microbial fuel cell affects the output voltage. My hypothesis was that if I use confluent wastewater, primary treatment wastewater, and secondary treatment wastewater in a microbial fuel cell, then the confluent wastewater fuel cell will have the highest output voltage, because confluent wastewater has the highest concentration of anaerobic bacteria.

Methods/Materials
I used the following materials when building (and using) the microbial fuel cell:

Confluent wastewater, primary treatment wastewater, secondary treatment wastewater, pure filtered water, Ziploc containers, PVC pipe, agar, sodium chloride, copper wire, carbon felt, resistors, air pump, airline tubing, Wye adapters, epoxy putty

Results
To investigate my hypothesis, I built four devices (per trial). I poured my independent variable (type of wastewater) into the container. One device held confluent wastewater, one held primary treatment wastewater, one held secondary treatment wastewater, and the last held filtered water. I tested each device for two weeks. After completing my testing, I found that my hypothesis was incorrect. The average output voltage of devices containing primary treatment wastewater was over 100 millivolts more than the output voltage of devices containing confluent wastewater!

Conclusions/Discussion
This experiment is extremely important regarding real-life applications. As stated by Hong Liu, a professor at Oregon State University, "If this technology works on a commercial scale the way we believe it will, the treatment of wastewater could be a huge energy producer, not a huge energy cost. This could have an impact around the world, save a great deal of money, provide better water treatment and promote energy sustainability" (Liu). This experiment proves that microbial fuel cells have the potential to be both cheap and efficient.

Summary Statement
I built a microbial fuel cell using cheap and accessible materials, and I tested which type of wastewater used in the fuel cell would generate the highest output voltage.

Help Received
I used lab equipment and created prototypes for my project under the supervision of Jenny Du, PhD.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Quan Ho; Giai Phan

Project Number

S1009

Project Title

The Effect of Acid and Enzymatic Hydrolysis of the Starch on the Decomposition Rate of Bioplastic

Abstract

Objectives/Goals

In this project, enzymatic and acid hydrolysis of the starch were performed to alter the structure of bioplastic. The alteration in the structure was then studied by comparing the decomposition rate of the two types of bioplastic that were made out of acid treated and enzyme treated starch.

Methods/Materials

The starch used to make the bioplastic was hydrolyzed in two different ways: with acid or with enzymes. All the bioplastic pieces were 2cm by 2cm and .5 cm thick. There were 10 bioplastic pieces hydrolyzed with enzymes and 10 hydrolyzed with acid. It was a total of 2 groups(Enzymatic or Acidic), each with 10 trials. The bioplastic pieces were then placed into film canisters with soil for decomposition. Then, each week(total of 6 weeks), it would taken out to have its mass measured with an electronic scale.

Results

The hypothesis was supported. The data showed that bioplastic that underwent acid hydrolysis had a decomposition rate of -0.052g/week and bio plastic that underwent enzymatic hydrolysis had a decomposition rate of -0.028g/week.

Conclusions/Discussion

Based on the data that was acquired from the experiment, the average rate of decomposition of bioplastic that was made out of starch that underwent enzymatic hydrolysis was found to be -0.027g/week and the rate of decomposition of bioplastic that was made out of starch that underwent acid hydrolysis was found to be -0.051g/week. The result of the experiment supported the hypothesis that was made. Bioplastic that underwent acid hydrolysis had the faster rate of decomposition.. During acid hydrolysis, amylopectin chains, the branches that diverge from the main amylose chain, are broken from the amylose chain. While the hydrogen ions in the acid along the water molecules break apart the bonds between glucose molecules by forming hydroxyl groups. During this process, amylose chains are also being broken since acid hydrolysis is not specific. The result that leads the weaker and less flexible bioplastic to a faster decomposition r ate. Enzymatic hydrolysis of the starch however, does not break apart the amylose chains into monomers of glucose because it is specific and targets only the alpha 1, 6 glycosidic bond. The result of a the bioplastic that was made out of enzyme hydrolyzed starch was a much stronger and orderly structured bioplastic that is less susceptible to decomposition.

Summary Statement

This project involved hydrolyzing the starch that was used to make the bioplastic with two different ways and the effect that these two methods of hydrolysis had on the structure was studied by decomposing the bioplastic.

Help Received

Ms Cooper helped improve experimental design, parents helped gather materials.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Jasper Huang

Project Number

S1010

Project Title

Manipulating Coarseness and Moisture to Enhance CO2 Sequestration by Basalt Sand and Red Harvester Ants as Biotic Agents

Abstract

Objectives/Goals

The objective is to determine if the rate of carbon sequestration by basalt sand with red harvester ants as biotic agents can be enhanced by varying sand coarseness and moisture in the sand. I hypothesized that a higher moisture content and finer coarseness will enhance the rate of carbon sequestration.

Methods/Materials

2 levels of sand coarseness and 3 levels of moisture content were tested, for a total of 6 combinations. 6 containers were set up, one combination for each container. The following were held constant for each experimental container: type of basalt (obtained from the basalt formation Table Mountain in Colorado), quantity of basalt, species of ants (Pogonomyrmex barbatus), quantity of ants (20 per container), and ant food. Controls were set up similarly: 6 were same as experimental group except without ants, 1 with ants only. In each container, carbon dioxide gas sensors connected to LabQuests (data-collection devices) recorded the levels of carbon dioxide (in parts per million) 30 times an hour for 5 days.

Results

Increasing water content increased the rate of CO(2) absorption while coarseness had no significant correlation with the rate in the given 5 day period. Both coarse and fine basalt containers with the maximum amounts of water had the greatest average rates at 0.37% and 0.35% decrease per hour respectively. Additionally, all controls for the soil had increasing or stationary CO(2) levels while all experimental groups showed decreasing CO(2) levels, confirming the ants# ability to enhance CO(2) absorption by basalt. The ants control had a nearly constant slope, showing that ants by themselves produce a negligible amount of CO(2).

Conclusions/Discussion

In conclusion, my hypothesis was partially supported. Higher moisture contents enhanced carbon sequestration rates while coarseness had no correlation with it. The simple combination of red harvester ants, basalt sand, and water may be the most natural way in mitigating CO(2) levels.

Summary Statement

This project tests the effect of soil coarseness and soil moisture content on the rate of CO(2) sequestration by basalt sand with red harvester ants as biotic agents.

Help Received

Dr. Ronald Dorn answered some questions I asked him; Dr. Stephen Wilson of the U.S. Geological Survey supplied basalt sand

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Seyvonne Ip

Project Number

S1011

Project Title

Functionalization of Polyacrylonitrile Nanofibers for Adsorption of Aqueous U(VI) Ions

Abstract

Objectives/Goals

The objectives of the research were to determine the effectiveness of uranium removal via electrospun nanofibers by verifying significantly increased adsorption of U(VI) ions on the amidoximated polyacrylonitrile nanofibers and to ascertain the greatest amount of U(VI) ions that could be adsorbed onto the nanofibers. The engineering goal was to facilitate the filtration of U(VI) ions from aqueous solutions and thus reduce radioactive contamination in the environment.

Methods/Materials

The polyacrylonitrile nanofibers were functionalized through wet chemistry by placing them in solutions of 0.375 g of hydroxylamine hydrochloride and 0.375 g of sodium hydroxide. To initially verify the effectiveness of uranium removal via functionalizing nanofibers, four experimental categories were used: deionized water, functionalized nanofibers in uranium-238 solution, unfunctionalized nanofibers in uranium-238 solution, and uranium solution with no nanofibers. After verification, to ascertain the greatest amount of uranium that could be adsorbed, the nanofibers were placed in concentrations of 50 ppb, 100 ppb, and 250 ppb uranium-238 solutions, and the same four experimental categories were used. Uranium uptake was given in counts per minute by Packard 1600CA Tri-Carb Liquid Scintillation Analyzer, and the percentage of uranium adsorbed was determined for each nanofiber mat.

Results

The functionalized nanofibers adsorbed an average of 94.10% of the uranium in solution over three trials, whereas the unfunctionalized nanofibers adsorbed 16.54% of the uranium. As the concentration of uranium increased from 50 ppb to 100 ppb to 250 ppb, the percent adsorption of the uranium on the functionalized mats decreased from 100% to 90% to 53%, respectively, indicating the existence of a loading capacity. The loading capacity of the functionalized nanofibers was determined to be 0.15 - 0.20 mg of uranium per 1 mg of nanofibers.

Conclusions/Discussion

The amidoximated nanofibers were effective sorbents for the removal of U(VI) ions from solution with more than five times the level of adsorption compared to the level of adsorption of the unfunctionalized nanofibers and adsorbed 0.15 - 0.20 mg of uranium per 1 mg of nanofibers. Further optimization of these versatile nanofibers will lead to significantly more efficient filtration of U(VI) ions, leading to their copious novel functions in the future.

Summary Statement

My project focused on functionalizing polyacrylonitrile nanofibers to adsorb U(VI) ions and ascertaining the loading capacity to facilitate the filtration of U(VI) ions in the environment to reduce radioactive contamination.

Help Received

Participant in Secondary Student Training Program at University of Iowa under Dr. Tori Forbes

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Christopher D. Isozaki

Project Number
S1012

Project Title
Reducing the Amount of Electricity Used by Computers Utilizing Green Technologies

Abstract

Objectives/Goals
With the energy crisis and environmental concerns in mind, I started a project last year to see if I could reduce the amount of energy used by computers that come from environmentally harmful sources and where possible, use green technologies. I achieved that goal last year but there were issues that made the product less than commercially viable. I decided that this year, my goals would be to resolve the issues, make it more efficient and still not use any wall supplied electricity. Those general issues included the following: (1)Ability to fit into a smaller space (2)Reduce the risk of condensation from the TEC. To make the cooling system more efficient, I wanted to address the following: (1)Better thermal interface material (2)More efficient TEGs (3)Better heat dissipation than aluminum fins (4) Better engineering

Methods/Materials
I created a variety of prototypes for this project and after each prototype, I performed an evaluation and made a list of issues that I wanted to resolve or improve. For the final configuration, I rearranged and condensed the size of the computer components to create a separate "cooling chamber". I installed an insulated wall to prevent the heat from going back into the main chamber. I used heat pipes to move the heat out of the main chamber and embedded the heat pipes in aluminum blocks to get better heat transfer. I placed two TEGs on the aluminum block in the cooling chamber and placed a vapor chamber on top to conduct the heat away and create a greater heat differential. I wired the TEGs serially and also connected a fan to create more airflow.

Results
My component testing verified the effectiveness of my thermal interface material, vapor chamber, heat pipes embedded in the aluminum block, new TEGs and insulation. This allowed me to design my final configuration. I ran the final configuration of the cooling system with the computer for over two hours, until it hit equilibrium, and the computer ran well and without any issues.

Conclusions/Discussion
Besides creating a computer cooling system that still didn?t need any wall supplied electricity, I achieved all the other goals I had set for this project and made a significant step towards making this a viable and implementable technology.

Summary Statement
Reducing the amount of electricity used by computers by creating a cooling system that does not use any wall supplied electricity

Help Received
My father helped with some of the machining and assembly of the cooling system and helped proof my documentation and board

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Jobaida, Marsha; Xu, Jingbing

Project Number

S1013

Project Title

Generating Energy through a Microbial Fuel Cell: Effects of Sodium Chloride

Abstract

Objectives/Goals

This project is based on determining how adding Sodium Chloride affects the power output of a microbial fuel cell. We hope to improve upon the environment through analyzing the impact of NaCl in a MFC. The need for renewable energy has driven our focus towards the MFC, a pollution free source. Electricity, a form of energy, with the use of bacteria in topsoil, can be harnessed through a MFC. However, this project is an initiation towards finding a rapid and more efficient method. We focus on using a basic mineral substance, salt, to improve upon the power output of a fuel cell. Finding the amount of energy the sodium chloride increases will be a step towards advancing energy for the world.

Methods/Materials

-Micro-Bio Fuel Cell kit:
* MFC vessel, * LED light, * Cathode, * Anode, * Hacker board, * Capacitor, * 7 different energy level resistors, * Multi-meter,
-Others:
* Top Soil, * Sodium Chloride (salt).

Results

As we took the power output everyday until the it seemed to stabilize, the power output of the peak power and all the other resistors slowly increased. The increasing trend was gradual at first, when we added the salt on the 8th day, the power output the next time we checked the power output instantly increased by more than 1 # 10-11. Bonding allows salt to speed up the reaction and delivers the energy faster to the LED light. By the 11th day, the excess amount of salt piling in the soil will cause the bacteria to slowly die off; this is why the power output has decreased.

Conclusions/Discussion

A fuel cell in general is an invention which generates electrical current that can perform work out of the cell, such as powering a light bulb, or an electrical motor engine. Fuel cells offer an efficient way to alternate the combustion of gasoline and other fossil fuels. With the use of chemical energy from hydrogen, electricity is produced, furthermore creating water and heat as byproducts. Fuel cells can be argued to be the most efficient energy generating solution ever invented, as they can run indefinitely due to the abundant source of hydrogen and oxygen. When we first thought of a project topic, we wanted something which could make a positive difference. After an amount of extensive research, we turned our attention to microbial fuel cells, and its focus on producing clean, renewable energy.

Summary Statement

Experimenting a new method to improve upon an alternate, clean, and renewable source of energy.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Maxime J. Kawawa-Beaudan

Project Number

S1014

Project Title

The Effect of Iron Sulfate Fertilization in Ocean Water on Phytoplankton Growth

Abstract

Objectives/Goals

The goal of this experiment was to test the effectiveness of iron fertilization as a method of fighting ocean acidification. As the ocean absorbs nearly 30% of the carbon dioxide in the atmosphere annually, it has become saturated in recent years with carbon dioxide, and subsequently carbonic acid, which robs marine animals of the building blocks for their shells. By adding iron sulfate, thus artificially creating phytoplankton blooms, one would decrease the levels of carbon dioxide through photosynthesis and restore balance to the system. This experiment tests whether, indeed, iron sulfate increases levels of phytoplankton.

Methods/Materials

Powdered iron sulfate from Alpha Chemicals

Results

This experiment showed that, following with the predictions, as the parts per million of iron sulfate increased, the biomass of phytoplankton increased accordingly.

Conclusions/Discussion

These results show that iron fertilization is indeed a promising technique for combating ocean acidification. Although this experimenter was unable to measure carbon dioxide levels, because of the expensive nature of carbon dioxide measuring systems, the large blooms of phytoplankton allow one to follow the logic that, because phytoplankton performs photosynthesis, absorbing carbon dioxide as a reactant, the sudden increase in phytoplankton would require a large intake of carbon dioxide.

Summary Statement

This experiment explores the effectiveness of a new method of fighting ocean acidification, and perhaps global warming: Iron fertilization.

Help Received

Parents purchased materials

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Lauren Kim

Project Number

S1015

Project Title

Developing a Device to Use the Products of Photocatalytic Water Splitting for Air Purification and Electrical Production

Abstract

Objectives/Goals

The goals of this project are to construct a device able to simultaneously apply the products of photocatalytic water splitting: hydrogen gas for electricity production through a fuel cell and hydroxyl radicals for air purification. This study hopes to accomplish this while keeping the device cost effective, safe to operate, sustainable, and portable while maximizing outputs. This project is an effort to increase commercial use of photocatalytic processes and efficiency was maximized through using an innovative combination of catalysts and structurally engineering the device.

Methods/Materials

In order to determine the optimal catalyst to use in the experiment, an aluminum mesh was coated with either 10g of ZnO, 10g of TiO2, or 10g combination of TiO2 and ZnO. A rectangular container was constructed using acrylic plastic panels and filled with water. The mesh was placed in the container and a fuel cell and multimeter were connected to the plastic container. A UV Lamp was placed directly above the container and measurements were taken every 10 minutes over the course of 60 minutes. After the most efficient catalyst was determined, air purification abilities of the device were measured through a PTRMS. The design of the device ensured that the hydrogen gas and hydroxyl radicals could only escape through slots in the container to oxidize pollutants or through tubing to the hydrogen fuel cell. The pollutants measured included formaldehydes, isoprene, acetone, and nitric oxide.

Results

A combination of TiO2 and ZnO proved to be 3x as effective than the catalysts used alone. The device#s shape and features were constructed to maximize surface area of the reaction. Hydrogen gas production was measured using a multimeter and the successful oxidation of pollutants by hydroxyl radicals was measured through a PTRMS. The device successfully oxidized over 80% of gaseous pollutants while producing a stable source of electricity. Studies are being conducted to observe how the device removes particulate pollutants from the air so that it may act as a comprehensive filtration system for a variety of areas.

Conclusions/Discussion

This device is a direct response to the problems of air pollution and energy and satisfies the original design goals. Ultimately, an affordable and effective device was constructed with promising results that have the potential to directly improve public health and accessibility to electricity.

Summary Statement

This project designed a dual photocatalytic air purifier and electrical source by using an innovative combination of catalysts and structural engineering to optimize both aspects of the device.

Help Received

Parents helped buy materials, Used lab equipment at UCI under the supervision of Dr. Sergey Nizkorodov

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Hope Lee

Project Number

S1016

Project Title

A Novel Method to Immobilize Ionic Liquid in Alginate-Gelatin Polymer Beads for Heavy Metal(s) Removal

Abstract

Objectives/Goals

The purpose of this scientific study was to design a novel, effective, and highly efficient immobilized ionic liquid approach towards removal of heavy metal(s) from an aqueous environment. It was predicted that increased amounts of ionic liquid would remove a greater proportion of the Cu2+ from the aqueous environment and that the system would be superior to traditional LLE in terms of efficiency, economic feasibility, and environmental impact.

Methods/Materials

This project was divided into three phases: (1) creation of immobilized polymer beads, (2) traditional Liquid-liquid extraction (LLE) to serve as a baseline for comparison for later phases, and (3) extraction with immobilized ionic liquid polymer beads. Viscosity and phase separation were selected as design of experiment (DOE) responses of the IL-alginate-gelatine system and achieve a stable and homogeneous solution. The JMP statistic software was used to construct response surfaces for both characteristics.

The ionic liquid chosen was trihexyl (tetradecyl) phosphonium bis (2,4,4-trimethylpentyl) phosphinate (CYPHOS IL 104), a synthesized organic compound which consists of ions of both charges and is liquid at room temperature. For this study, copper ion (Cu2+) was selected as a model system to demonstrate the immobilized CYPHOS IL 104 concept. Gelatin and sodium alginate were selected to immobilize and stabilize IL in a polymer matrix.

Results

The optimized composition for the immobilized ionic liquid solution was identified through a DOE model as approximately 0.33% gelatin (w/w), 0.33% sodium alginate (w/w), and 33% IL (w/w). The immobilized IL beads ultimately removed a maximum of over 98% of Cu2+ from 6 mL of 50 mM Cu2+ solution. No extraction efficiency was compromised through immobilization. The immobilized IL beads were successfully stripped and regenerated by 1N NaOH and was able to remove over 98% of Cu2+ from 6 mL of 50 mM Cu2+ solution when used again.

Conclusions/Discussion

Ultimately, it was concluded that the novel immobilized IL-alginate-gelatin method did not compromise the extraction efficiency of the ionic liquid. This new approach, in comparison to LLE, greatly saved time, energy, and materials and prevented the IL contamination of water during extraction. This research has great potential in the field of water treatment and rare earth metal(s) extraction and adheres to the USEPA principles of green chemistry.

Summary Statement

The purpose of this scientific study was to design a novel, effective, and highly efficient immobilized ionic liquid approach towards removal of heavy metal(s) from an aqueous environment.

Help Received

Father supervised while working at home

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Jessica M. MacMillan

Project Number
S1017

Project Title
Amoeba Filtration to Reduce Cholera Outbreaks

Abstract

Objectives/Goals
Missions has always been a big part of my life. I am passionate about loving people and helping them in any way I can. I am interning in South Africa over the summer doing missions work with an emphasis on environmental engineering. I want to take my findings from this project and apply them during my internship this summer. There is a need for people to know the skills, such as those I tested in my project, to reduce cholera outbreaks. This problem is easily preventable with the right practices, and I want to provide accessibility to the information to prevent it.

Methods/Materials
In my project I used T-shirts, chiffon, and dry fit as my filters and amoeba from Flinn Scientific, inc. and Carolina. I used a Moxi Flow Cytometer & cassettes from Orflo to count amoeba in the water. I also used various test tubes and beakers in my lab.

Results
Of my 16 tests, 14 filtered in the 90%-100% range. There were a few outliers, but for the most part the filtration was successful. This cannot completely filter amoeba from the water, but it can filter 90%-100% reliably. If amoeba can be filtered then when cholera attaches to it, creating an even bigger particle, the filtration rate should go up even more.

Conclusions/Discussion
Consistent with all of the fabrics, the test with two layers filtered more than the tests with a single layer. Both cotton and chiffon followed the same trends even though, as a whole, chiffon was more successful. The tests with three and four layers were both less than the prior tests which was interesting. The only test that did not follow this trend was the dry fit material, which followed a more logical pattern of filtering more with each additional layer. There could be any number of reasons that this could be true, the cell counter could have counted incorrectly, or there could be abnormalities in the fabric. Another possibility is that with more layers of fabric comes a slower filtration rate, at least on the small scale. Pouring the water with amoeba through, I would have to stop to allow time for the water to filter through before pouring more to not flood the fabric. While pouring slower it could allow more time for the amoeba to pass through the fabric thus creating a lower filtration rate as was observed in the results.

Summary Statement
Since cholera attaches to amoeba in some areas of the world, I am filtering amoeba from water using easily accessible materials to create a design that reduces cholera outbreaks that will be realistic for people in poverty.

Help Received
Dr. Rita Huff, my teacher, supervised my project and use of equipment at school

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Priya Padmanaban

Project Number

S1018

Project Title

The Synthesis of Ferromagnetic Nanoparticles for the Decontamination of Oil-Polluted Water

Abstract

Objectives/Goals

Finding a way to decontaminate oil-polluted water would benefit the health of aquatic organisms as well as the quality of the water. An attempt is made here to use ferromagnetic particles to clean up oil spills.

Methods/Materials

A ferrofluid was synthesized using ferric chloride, ferrous chloride, aqueous ammonia, and tetramethylammonium hydroxide (as a surfactant). Five different concentrations of ferrofluid (0.02, 0.04, 0.06, 0.08, and 0.10) were tested with 100 mL distilled water contaminated with 8.5 mL of oil. The ferromagnetic particles, which were suspended in the ammonia and water solution, mixed with the oil upon contact and made it possible for the oil to be removed with a magnet. The oil was extracted using ferrofluids from all groups at 3 points in time: immediately, after 24 hours, and after 48 hours.

Results

The experiment with 0.08:1 ratio of ferrofluid to water (8 mL of ferrofluid for every 100mL of contaminated water containing 8.5% oil) was the most effective, removing about 94.24% of the oil from the water. The 0.06:1 ratio of ferrofluid to water was very close and removed 92.4% of oil from the polluted water. Highest concentration of magnetite with 0.1:1 ratio of ferrofluid to water consistently removed less oil than the 0.08:1 ratio, even though it contained more ferrofluid. The lowest ratio tested (0.02:1) was least effective, removing just 55.65% of the oil from the water. Extending the exposure time of the magnetite to the oil for 24 and 48 hours did not significantly increase the amount removed.

Conclusions/Discussion

Oil spills, such as the Deepwater Horizon crude oil spill that occurred in the Gulf of Mexico recently, are extremely worrisome. Based on the results, ferrofluids definitely have potential for decontaminating water of oil. While the ratio of 0.08:1 was the most effective, the effectiveness of the ferrofluid increased as the concentration increased, with the exception of the highest concentration used (0.1:1 ratio of ferrofluid to water). This may be due to the fact that such a large amount of ferrofluid was not miscible with the water and oil completely and thus reduced the effectiveness of the ferrofluid. Although it may not be cost effective, a ferrofluid made with harmless chemicals that does not affect the health of aquatic organisms may help decontaminate the water fairly effectively.

Summary Statement

This project tested the effectiveness of a synthesized ferrofluid on the extraction of oil from oil-polluted water.

Help Received

Used labs at Silver Creek High School; Received guidance from Mr. Cervantes.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Atul Raghunathan

Project Number

S1019

Project Title

Harvesting the Excess Thermal Energy Produced by Light Emitting Diodes to Generate Electricity

Abstract

Objectives/Goals

Current LED Technology converts electricity into light very efficiently compared to incandescent or fluorescent light bulbs; however around 5-40 percent of electricity supplied to LEDs is converted to heat. The LED bulbs use large bulky heatsinks to extract this heat from the LED. This heat is radiated into the surrounding air and wasted. This project aims to replace the standalone heatsink with an inexpensive thermoelectric generator, which recaptures part of this thermal energy and converts it into electricity. I intend to convert the thermal energy produced by a Cree Xlamp CXA 1304 into electricity of at least 3 milliwatts.

Methods/Materials

I constructed an apparatus using a Peltier wine cooler as a thermoelectric generator. I used a steady source of DC current from a nickel cadmium battery and 3.3 ohm resistors to provide the three LEDs with the current specified by the manufacturer. I used a 2.7 ohm resistor and a multimeter to measure the amount of power generated by using ohm's law. I charted the data every five seconds and continually modified the design until I received consistent results. The fifth and sixth prototype delivered consistent results with the sixth one demonstrating the scalability of the fifth version. With the data collected, I was able to generate an accurate representation of power over time. This enabled me to create a function that was able to predict the future data.

Results

The thermoelectric generator was able to produce 166 milliwatts at first, but that declined and stabilized at 86 milliwatts. In the fifth prototype, the LED was 80-90 degrees cooler with use of the thermoelectric generator; it reduced the temperature on an average from 210 degrees to 120 degrees Fahrenheit.

Conclusions/Discussion

I created a mechanism that effectively draws heat away from an LED to generate electricity. My experiment shows that the decrease in temperature caused by utilization of the thermal energy increases the lifespan of the bulb by 10 years. In addition to this, utilization of these devices save between 101-253 kilowatts of power in an average American home.

Summary Statement

I created a device that increases the lifespan of an LED by efficiently drawing heat away and uses that heat to create electricity.

Help Received

Mr. Charles Williams helped with soldering and machining of apparatus.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Mikaela M. Troxell

Project Number
S1020

Project Title
Anaerobes to Power? A Scientific Approach in Creating Methane from Manure and Trash

Abstract

Objectives/Goals
Cow manure has Obligate Anaerobes present which decomposes and converts cow manure to gas with the right environment. What is added to the cow manure can cause a variation in the fermentation. Bananas, for example will break down into sugar, hydrogen, carbon, ethylene, and other nutrients. These components can speed up or increase the production of methane gas. The benefits of this experiment is to think about how a waste product can be use to support our need of natural resources so our country will not depend on fossil fuel. The objective of this experiment is to prove that with an environment that is oxygen free, added decomposing table scraps, and a heat lamp to maintain a warm temperature, methane gas can be formed at an increased rate.

Methods/Materials
Using a scale measure out 20 g of cow manure and 20g of mashed bananas and scoop it inside the water bottles. Place half the water bottles in the heated box and the rest of the bottles outside of the heated box. Record your results for 8 days. Measure the girth of the balloon three times per day for 8 days. Also record the temperature inside and out side the heated environment for the 8 days. Math formula V=4/3(pi)(radius cubed), was used to solve for the volumes gathered.

Results
The data collected below shows the rate of growth of three trials. It clearly shows the banana and manure mixture can make the most gas with warmer temperatures. The average temperature during experiment was 69.3°F in the morning, 73.0°F in the afternoon, and 67.11ºF during the evening in the heated area. The average temperature outside of the heated area was 46.75°F in the morning, 55.3°F in the afternoon, and 44.08°F in the evening. The average temperature was used to show results on graphs.

Conclusions/Discussion
In conclusion, bananas, manure and an added heat source produced the highest amount of gas. This was evident because the balloon circumference of the banana, manure with added heat was the largest for each trial. During fermentation bananas tend to produce high levels of glucose and hydrogen which helps the anaerobes produce more methane gases. This cannot occur without heat which allows the microbes to become more active. I would also like to conclude that temperature has an affect on anaerobes and the fermentation process.

Summary Statement
This project is focused on anaerobic microbes used to create methane gas.

Help Received
I did my research independently of any outside help other than insight from my high school teachers. My parents assisted in buying supplies and proofreading my research.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Rafael D. Velazquez-Ramos

Project Number
S1021

Project Title
Manure Is Your Friend

Abstract

Objectives/Goals
To determine biogas production from different biodegradable material contained with equine manure in the digesters.

Methods/Materials
plastic 5 gallon water bucket
Large Mylar helium balloon
vinyl tubing size ⅜
Stirring rod made from wood
20 gallon tank

Results
For my experiment I conducted four trials to test the biogas production of horse manure with different fruit waste which were banana skins, papaya peel, and orange rind. Then during trial two I came across cold winter months and the anaerobic bacteria do not become active in cold temperatures. In trial three I added an electrical heated blanket that was plugged into the wall during school hours. The blanket generated a temperature of 155℉, at the base of each digester. TThere was finally a fourth trial done where the digesters were under natural sunlight due to greater sunlight availability. During trial four the highest rate recorded was the orange rind digester with an average of 78.6 millimoles of biogas, followed by the papaya peel digester with 75.8 millimoles of biogas then by the horse manure (control) with 77 millimoles of biogas, and finally the lowest rate the banana skin digester with 68.5 millimoles of biogas. Overall the orange rind digester had a higher production of biogas, than papaya peels, banana skins, and the horse manure (control). This was due to the pH. In trial four the digesters were carefully observed for their pH under 31 days of incubation.

Conclusions/Discussion
My hypothesis was that the orange rind would produce more biogas than papaya peel, banana skin, and horse manure. My results do support my hypothesis. Each of the digesters proved to make biogas, which is a renewable energy that can be burned to generate power. In the experiment, orange rind had more production of biogas in three out of the four trials than the papaya peel who was always second in biogas production, and horse manure was third in production, leaving banana skin fourth with least producing amounts of biogas.

Summary Statement
My project is about reusing horse manure and creating renewable engery to impact the horse industry.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Jaime E. Wood

Project Number
S1022

Project Title
The Effect of a Fresnel Lens upon Solar Still Productivity

Abstract

Objectives/Goals
This experiment is intended to determine how a Fresnel (magnifying) lens affects the water output of a solar still. The outcome of this research could possibly provide insight to help increase the productivity of solar stills.

Methods/Materials
Two hundred grams of distilled water were placed in a solar still with a standard glass window and 200 grams distilled water were simultaneously placed in a solar still with a Fresnel lens, each beneath its own five hundred watt light fixture, then the output of each still was measured and compared.

Results
The still using the Fresnel lens produced a greater amount of water than the control still. On average the test still produced 47.1 grams of water, compared to the 32.6 grams produced by the control still during 120 minute trials. The data show a statistically significant 44% increase in water production when a Fresnel lens was used to concentrate the light. The control still maintained a consistent level of water production throughout the
trials.

Conclusions/Discussion
The Fresnel lens captured light energy and concentrated it into one focal point in the tray of water below, efficiently evaporating and condensing more water than the control still. A solar still using a Fresnel lens could potentially collect 44% more water than a typical still, a notable increase in water production. Future research and trials need to be conducted under natural sunlight.

Summary Statement
The use of a Fresnel lens on a solar still resulted in a 44% increase in water production.

Help Received
Father helped construct solar stills and helped perform T-test analysis in Excel

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Sanika S. Mane

Project Number
S1098

Project Title
Alternative Energy: Producing Second Generation Biofuel from Inedible Biomass

Abstract

Objectives/Goals
Increased use of edible biomass in the production of first generation bio-fuel has been a leading cause of increase in food price index and world hunger. The alternate fuel companies depend heavily on edible biomass such as corn and sugarcane to produce ethanol as the first generation biofuel to run vehicles. To swerve around this issue, producing biofuel from inedible biomass will benefit humanity by not interfering with the world#s natural edible resources.

Methods/Materials
To illustrate the prototype production of second generation biofuel, experiments were designed to demonstrate the type of cellulose source, enzymes, and chemicals best suited in a hydrolysis reaction to produce glucose which can be fermented into ethanol. For second generation biofuel, many types of inedible plant material can be used, since cellulose from different biomass sources have the same molecular structure. Sources of inedible cellulose were wood, leaves, and stalk. Simultaneously, another experiment was conducted to determine the amount of glucose produced from edible biomass such as corn. Glucose production data from corn was compared with the inedible biomass glucose production to determine whether the inedible biomass has a higher or lower volume. To conclude which catalyst is most advantageous, comparison was done on the amount of glucose produced in a specific reaction, using the Dinitrosalicylate Colorimetric method. A Spectrophotometer was used to collect quantitative data from the experiments. By measuring and observing the absorption rate of each substance after it undergoes the chemical reaction, we can demonstrate the type of enzyme or chemical in which cellulose source is most beneficial in producing the second generation ethanol based biofuel.

Results
Cellulose sources produced glucose in a range of 0.626 to 2.363 mg/DL with an average production of 1.531 mg/DL, with the exception of Pectinase compared to 1.412 mg/DL of glucose produced in corn.

Conclusions/Discussion
Glucose extraction from inedible biomass has been demonstrated to be compatible in volume of edible biomass. Inedible biofuel can be produced economically without using food cultivating land as a source and without risk to environment or threat to living beings. I regard inedible biomass fuel as an emerging trend and need for replacement of corn based ethanol. The inexhaustible FUEL has arrived.

Summary Statement
Producing 2nd generation biofuel from inedible biomass as an alternative for extracting ethanol biofuel from edible biomass.

Help Received
Used lab facilities at Vista Del Lago High School under the supervision of Chemistry and Biology teachers including Mrs. Holbert, Mr. Ashwell, Mrs. Baker, Mrs. Moore, and Mr. Lancaster. Family helped in assembling together the display board.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Julie A. Fukunaga

Project Number
S1099

Project Title
An Internet of Things Application for Aquaponics

Abstract

Objectives/Goals
The purpose of this project is to build an efficient Internet of Things (IoT) application for aquaponics in order to create an autonomous, self-regulating system that can be remotely-controlled by the user through the Internet. The IoT aquaponic platform is composed of devices that can sense and collect information from their environment, store it in a cloud database, and transmit it to an Internet web server.

Methods/Materials
The aquaponic system includes an indoor tank and grow bed with several varieties of vegetables, 5 goldfish, a 15 gallon grow bed, and a 20 gallon tank. A Raspberry Pi 2 is connected to a pH meter, camera, and an ambient light, water level, and room/water temperature sensor to provide data to the user. In the IoT network, multiple actuator devices such as a heater, grow light, feeder, and water and oxygen pumps can be programmed to activate or turn off based on conditions monitored by the sensors and/or set by the user. The aquaponic system utilizes computer programming to create an interactive web server written in JavaScript and HTML in which the user can access and control from the Internet while storing data collected from the device on a cloud web-hosting server. This web application provides a graphical representation of live data from the sensors, as well as a video feed of the tank.

Results
A functional live-streaming web application was created to monitor and control the conditions of the self-regulating aquaponic system with the ability for user access and control of various sensors and devices according to the system and user's needs.

Conclusions/Discussion
The design criteria and engineering goals were met. The aquaponic system is more efficient by integrating the Internet of Things (IoT) and maintains a self-monitoring aquaponic system as a smart and sustainable improvement to conventional techniques, which often require human manual labor. The web server accessible to the user provides live data collected by sensors to help him or her monitor and regulate the tank conditions. Such technology can be integrated into wastewater treatment, pool maintenance, and other water monitoring industries.

Summary Statement
I built an autonomous and/or remotely-controllable aquaponic system that stores data collected from lighting, pH, temperature, moisture, and water level sensors in a cloud database that can be accessed and controlled via the Internet.

Help Received
My father mentored with the computer programming, Sweet Leaf Hydro showed the different designs for the aquaponic system, and Kathy Grant, Lodi's Stormdrain Detectives coordinator, provided the dissolved oxygen meter.