030207

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Intermediate / Environment

Shrubs on Drugs

The prevalence of prescription medications in North American bodies of water are rapidly contributing to the deterioration of the environment. To discern the effect of prevalent medications on plant life, Metformin and Crestor were introduced to fenugreek seeds at different concentrations. Uncontaminated, bottled water was used as a control and the effects of the medications were observed over 15 days.

Project Forms

Project #030207 - Shrubs on Drugs

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Background: The prevalence of prescription medications in North American bodies of water are rapidly contributing to the deterioration of the environment. Ingested medications are gradually passing through sewage treatment facilities and accumulating in The Great Lakes[5]. Because only a fraction of ingested medication is metabolized by humans, chemicals are often excreted with feces, urine, and sweat. Sewage treatment plants are not equipped to filter pharmaceuticals and personal care products (PPCPs) from waste[3]. A study conducted by the U.S. Geological Survey in 1999-2000 revealed one or more chemicals to be present in 80% of the water samples collected from 139 streams[1]. Cholesterol medication, similar to the Crestor used in this experiment, and Metformin, a medication used to treat diabetes 2, were among the chemicals found[3].

Metformin is a predominant diabetes medication emerging in Lake Michigan at significant concentrations[5]. It appeared at concentrations of 40 parts per billion in close vicinities to sewage treatment plants, falling to 120 parts per trillion 2 miles away from the plants[4]. 76.9 million prescriptions of Metformin were dispensed in America in 2014[8]. Its prevalence in the environment is fairly proportional to its excessive use as a treatment for a common ailment. Humans don't metabolize Metformin so when the medication is excreted, it is effectually unchanged and it is also stable against UV irradiation, a treatment typically used to break down chemicals in water[8]. A trial conducted in 2015 exposed fathead minnows to concentrations of Metformin equivalent to those in Lake Michigan. Within 4 weeks, male minnows were exhibiting signs of feminization. They were creating proteins found only in female fish,

weighing less, growing ovarian masses internally, and producing fewer offspring[6]. The trial was indicative of Metformin being an endocrine disruptor, affecting the production of hormones[2].

Remediation of a contaminated area conventionally requires the pollutant to be physically removed. However, in instances similar to the PPCPs present in bodies of water, phytoremediation has been used to rid a region of its toxin. Phytoremediation is the use of plants to extract or degrade a contaminant from soil and groundwater. The plants use photosynthesis to extract the chemicals to surfaced parts of their structures, where they can be degraded by the plant or harvested and broken down artificially[7]. Phytoremediation has not yet been applied to filtering out chemicals already present in a body of water and the technology is limited in the contaminants it can remove. Extending the mechanisms of phytoremediation to swamps around lakes or shoreline plants could allow for the filtration of larger bodies of water, or the prevention of contaminants from entering the water.

Purpose: The purpose of the experiment was to determine the effect of the prescription medications, Metformin and Crestor, in different concentrations on trigonella foenum-graecum (fenugreek), and if it is possible to lessen the effect of the medications on plant life through filtration. The rates of growth and qualitative health exhibited by the plants would establish a precedent for how well the plants absorb medications and grow in environmentally inadequate conditions.

Hypothesis: The presence of the medication will be harmful to the plant, chemically impacting its rate of growth, hormones, ability to photosynthesize, and ability to absorb nutrients. Therefore, as the concentration decreases, the health of the plant will increase in response to the reduction of a toxin in it's environment. If the plants are watered with filtered concentrations,

they will grow better than their medicated counterparts because the process of distillation will have removed some of the medication from the solution. If the plants are watered with the control, they will grow better than the filtered and medicated samples because no concentration of medication would be introduced into their environment.

Procedure: The trial was conducted over 18 days with 4 samples per solution and 7 solutions with different concentrations of medications. The solutions were: *1mg/ml Metformin*, *0.5mg/ml Metformin*, *Filtered Metformin*, *0.04mg/ml Crestor*, *0.02mg/ml Crestor*, *Filtered Crestor*, and a *Control* of uncontaminated water. The concentration of each solution was calculated by dividing the mass of the pill by the volume of water it was dissolved in.

Creating initial solutions: 7 500ml bottles were labelled with one solution each. A 500mg Metformin pill was dissolved into 500ml of water (creating a concentration of 1mg/ml). 200ml of the dissolved *1mg/ml Metformin* water was poured into a measuring cup with 200ml of water to create 400ml of *0.5mg/ml Metformin* water. Each solution was poured into its corresponding bottle. This process was repeated with Crestor, creating the *0.04mg/ml Crestor* and the *0.02mg/ml Crestor* solutions. To create the *Filtered Metformin* solution, another 500mg Metformin pill was dissolved into 500ml of water, poured into a coffee percolator, heated until evaporation in 75ml segments, cooled in a heat safe bowl and poured into the corresponding bottle. The distillation process was repeated to filter Crestor. Solutions were recreated on Day 7.

Growing the samples: 28 fenugreek seeds were placed in a 100ml container filled with 50ml of water and left to germinate in an area with consistent amounts of sunlight for 3 days. 4 paper pots were designated for each type of solution, labelled with an abbreviated version of the solution name, numbered 1-4, and placed on a tray with the same label. Each pot was filled with

7cm of potting soil with a small hole where one germinated seedling was planted. The holes were covered with more potting soil and each pot was watered with 10ml of its corresponding water. The samples were watered with 10ml each on alternating days from when they were initially planted and height was recorded daily for 15 days. On the 15th day, qualitative observations were recorded for all samples.

Results: The results showed differences between the control and test samples over a 15 days. Because the samples all sprouted at different times, their final height and amount of growth during the 15 day time period was not comparable. To determine the effects of each medication on the plants, qualitative healthiness was observed and the rate of growth was determined through graphical technologies.

Control Results: The *Control* grew qualitatively the healthiest and had the second highest growth rate. Only 3 out of 4 of the control samples sprouted, but they grew an average of 0.30cm per day.

Metformin Results: As the concentration of Metformin increased in the water, the average growth rates of the plants decreased. The plants grown in *Filtered Metformin* water grew better than plants grown in unfiltered concentrations, indicating the distillation had decreased the concentration of the medication. Although the *Filtered Metformin* samples grew to similar heights as the control, they had weaker stems and had collapsed by the end of the trial. Metformin, although introduced in higher concentrations than the Crestor, had samples which grew healthier with higher growth rates, suggesting the toxicity of Crestor to plants. The *Filtered Metformin* plants grew an average of 0.31cm per day. The *0.5mg/ml Metformin* plants grew an average of 0.26cm per day. The *1mg/ml Metformin* plants grew an average of 0.17cm per day.

Crestor Results: None of the *0.04mg/ml Crestor* plants sprouted, therefore the heights and rates of growth of the 0.02mg/ml concentration could not be compared. However, the plants grown in *Filtered Crestor* water grew healthier and faster than the *0.02mg/ml Crestor* concentration, indicating the health of plants would increase if the concentration decreased. The *Filtered Crestor* plants grew an average of 0.19cm per day. The *0.02mg/ml Crestor* plants grew an average of 0.15cm per day. The *0.04mg/ml Crestor* plants did not sprout.

Conclusion: The presence of Metformin and Crestor at the concentrations introduced in the experiment had a negative effect on fenugreek seeds, with plants exhibiting lower growth rates than the control. Although filtration did not negate the effect of the medication, it did remove some of the contaminant from the water, as observed through the health of the plants grown with filtered water. Crestor is more harmful to plants than Metformin because although it was introduced at lower concentrations it had a larger effect on its samples. Fenugreek grown in filtered Metformin water appeared to have experienced changes in hormones, specifically those controlling the production of cells for the stem, making the plants grow fast but not healthily. This effect could be similar to the hormonal unbalance observed in male fathead minnows when exposed to Metformin. The results display the potential for plants to intake substances with water, regardless of whether they are traditionally absorbed. Although the chosen medications have a negative effect on plants when introduced at the high concentrations used in this trial, plants could hypothetically sustainably absorb medications at the concentrations found in the environment and act as a biofilter.

References

1. Buxton, H. T., & Kolpin, D. W. (2002, June). Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams. Retrieved from https://toxics.usgs.gov/pubs/FS-027-02/

2. Diabetes drug found in freshwater is a potential cause of intersex fish. (2015, April). Retrieved from www.sciencedaily.com/releases/2015/04/150424141753.htm

3. Drugs in the water. (2011, June). Retrieved from http://www.health.harvard.edu/newsletter_article/drugs-in-the-water

4. Ellison, G. (2015, January). Type 2 diabetes drug found in Lake Michigan affecting fish, researchers say. Retrieved from http://www.mlive.com/news/index.ssf/2015/01/metformin_lake_michigan.html

5. Kedmey, D. (2015). Ingested Drugs, Passed Through Sewers, May Threaten Lake Michigan Fish. Retrieved from http://time.com/3666985/pharmaceutical-drugs-sewers-lake-michigan-fish/?iid=sr-link1

6. Niemuth, N. J., & Klaper, R. D. (2015). Emerging wastewater contaminant metformin causes intersex and reduced fecundity in fish. *Chemosphere, 135*, 38-45. doi:10.1016/j.chemosphere.2015.03.060

7. Pocket K No. 25: Biotech Plants for Bioremediation. (2006, November). Retrieved from http://www.isaaa.org/resources/publications/pocketk/25/default.asp

8. Scudellari, M. (2015, August 1). Drugging the Environment. Retrieved March 31, 2017, from http://www.the-scientist.com/?articles.view/articleNo/43615/title/Drugging-the-Environment/

Bibliography

Blair, B., Crago, J., Hedman, C., & Klaper, R. (2013). Pharmaceuticals and personal care products found in the Great Lakes above concentrations of environmental concern. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/23973285.

Matheny, K. (2015, January). Diabetes drug affecting fish in Lake Michigan. Retrieved from http://www.freep.com/story/news/local/michigan/2015/01/13/metformin-diabetes-drug-olution-lake-michigan/21734507/

Muskegon Lake's Contaminated Sediment Cleaned Up by Poplar Trees. (2014, August 27). Retrieved April 24, 2017, from http://www.healthylakes.org/successes/restoration-success-stories/muskegon-lakes-contaminated-sediment-cleaned-up-by-poplar-trees/