RUNOFF CONTAINING DISINFECTANTS BEING OVERUSED DURING THE COVID-19 PANDEMIC MAY HAVE NEGATIVE IMPACTS ON PLANT LIFE

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ABSTRACT

The current COVID-19 pandemic has led to many Americans using an excessive amount of disinfecting cleaning products. Panic amongst citizens and the need to protect human health resulted in an unprecedented amount of these chemicals being used. Chemical runoff of these products spread into the surrounding ecosystem threatening the local fauna and flora. To study the effects of disinfectants on plant life, we treated five different species of plants with hand sanitizer and bleach. Our results show that disinfecting substances have a highly negative effect on all plant life, greatly reducing the lifespan of the plants. Plants that were treated with the bleach solutions expired quicker than those treated with the hand sanitizer solutions. Therefore, we can hypothesize that chemical runoff due to the overuse of disinfectants during the COVID-19 pandemic has a detrimental effect on the environment.

Keywords: Bleach, COVID-19, Disinfectants, Plants, Sanitizer

INTRODUCTION

Due to the current COVID-19 pandemic, many American citizens in rural and urban areas have been using an excess of cleaning products. Whether in residential homes, hospitals, stores, or factories, high amounts of chemicals being used will lead to the risk of chemical runoff affecting the environment**.** The extent in which chemicals are being used to combat the COVID-19 pandemic is unprecedented. The state of panic of American citizens and desire to protect human health results in overuse of certain cleaning products, which in turn poses a risk to human health and the environment. Exposure to these chemicals increases the risk of developing cancer, COPD, asthma, and other health conditions (Rai 2020)**.**

It is well known that weather related run-off can cause chemicals to spread into the surrounding ecosystem, producing negative effects on the environment (Sakai et al. 2004). Studies from the early 2000's have proven that increased risk of chemical run off detrimentally affects more urban environments. This is believed to be true for a multitude of reasons, such as the vulnerable layout of urban environments as well as the increased use of chemicals in urban as opposed to rural areas. Furthermore, this study concluded that run off originating in urban environments is highly responsible for nutrient

pollution (Sakai et al. 2004). Additionally, it was concluded that common pharmaceuticals have been linked to endocrine disorders in certain organisms due to exposure through chemical runoff. These chemicals can penetrate the soil through sewage, bio-solids, and irrigation (Ohoro et al. 2019). The impacts of chemicals can be unexpected, and can occur even as a result of small concentrations (Russo et al. 2020). All species of plants are impacted by human actions, from urban woodlots to rare medicinal plants (Ganie et al. 2019, Fornal-Pieniak et al. 2019).

Hospitals and other medical facilities are also sources of toxic waste. Rao et al. (2004) believe that hospital waste poses a threat to public health and the environment. Rahman et al. (2020) agree and stress that due to COVID-19, excessive biomedical waste is the newest danger to public health and the environment. Scientists in Romania have explored the idea of waste flow worsening the pandemic. The possibility for virions combined with chemical waste from hospitals and medical facilities will undoubtedly cause damage to human life (Mihai 2020). Due to the severity of the pandemic, proper waste flow and monitoring has been deemed less important than other pressing issues surrounding COVID-19 in many countries across the globe. What gets ignored specifically, is the threat that improper waste flow poses to the environment (Mihai 2020).

In some parts of the world, large quantities of disinfectants are being applied onto roads, commercial, and residential areas to exterminate the COVID-19 virus. Such extensive use of disinfectants may kill beneficial species, which may then create an ecological imbalance (Rume and Didar-Ul Islam 2020). Russo et al. (2020) found that chemicals could disperse into the air, surface and groundwater which would then expose natural plants. They stress that ruderal, disturbance-tolerant plants that many insects rely on are also exposed to these chemicals.

The main substances that we are concerned with during this project are hand sanitizer and bleach, since these are the substances that are being overused the most during the COVID-19 pandemic. In fact, due to the public's need for these products, the FDA has decreased some of their regulations surrounding the content and production of hand sanitizers. High demand of disinfectants, combined with the WHO's advice of cleaning outdoor surfaces with these disinfectants, has ultimately led to their mass production and use in ways that could pose harm to the environment (Fairgrieve et al. 2020). Studying the impacts of such chemicals is important, as it is not uncommon for byproducts of certain production processes to actually be beneficial to plants, such as carbon byproduct materials (Kumar et al. 2020).

We aimed to explore in detail the effects of chemical run off and improper waste flow on natural plant life. It was hypothesized that our group would find evidence of a negative impact on natural plant life under simulated chemical runoff conditions.

METHODS

To determine the effects of improper waste flow on natural plant life caused by COVID-19 disinfectants, our group conducted an experiment to see if several simulated waste flows would have an impact on the growth of common plants. To do so, each member of our group had to purchase five plants of the same species (plant species differed between members to cover a larger band of plant life) along with Clorox brand bleach and a 60%-80% alcohol content store bought hand sanitizer to be our disinfectants. The plants that we have acquired are as follows; Violets (Viola), Mums (Chrysanthemum), hostas (Funkia), and Kale (Brassica oleracea var. sabellica). Five plants were chosen so that there would be one plant designated to test each of the experimental groups: a 10% bleach solution, 50% bleach solution, 10% sanitizer solution, 50% sanitizer solution, and a control of plain water.

Each member of the group set up their individual plant species either indoors or outdoors (positions of plants varied between group members due to member locations). The mums were kept outdoors throughout the experiment, the kale and violets were kept indoors, and the hostas were outdoors,

until a frost warning was issued, at which point they were brought indoors. The plants, regardless of species/group members, were separately potted and labeled to keep track of each experimental group and to test the effects of disinfectant runoff simulated by watering the soil with Clorox bleach and hand sanitizer solutions. While runoff is not controlled in nature, each species of plant was watered on a "as needed" schedule. After the first full day of the disinfectant solution treatments, we began our daily data collection. We recorded the percent dead of each plant by comparing the amount of living vegetation to the dead/yellowed vegetation and was all to be recorded in an excel file for later analysis.

Each group member utilized the same, or very close to the same, materials. This included 5 individual plants of differing species per member. Every group member used Clorox brand bleach to ensure consistency; hand sanitizers ranging from 60%-80% isopropyl alcohol concentration were used in efforts to maintain consistency as well. Plain tap water was used as a control across each experiment. Further, a liquid volume measuring tool was used to create each solution and ensure that ratios were consistent across experiments. Those recording height utilized centimeter rulers to mark their findings. All photos presented were taken on each members' individual cameras. Lastly, an excel file was used to record and share all collected data over the course of the experimental period.

RESULTS

After performing a paired t-test, we found a significant difference before and after applying the 10% hand sanitizer, 50% hand sanitizer, 10% bleach, and 50% bleach treatments ($p<0.05$ for all treatments). We did not find a significant difference before and after treating the plants with water ($p=0.14$).

As expected, the 50% bleach and hand sanitizer solutions had larger impacts on the plants than their 10% counterparts. Most of the control plants didn't wilt much, with the exception of the hostas. This was likely due to overwatering or other factors. None of the plants seemed to be more resistant to the effects of the cleaning chemicals than any of the others.

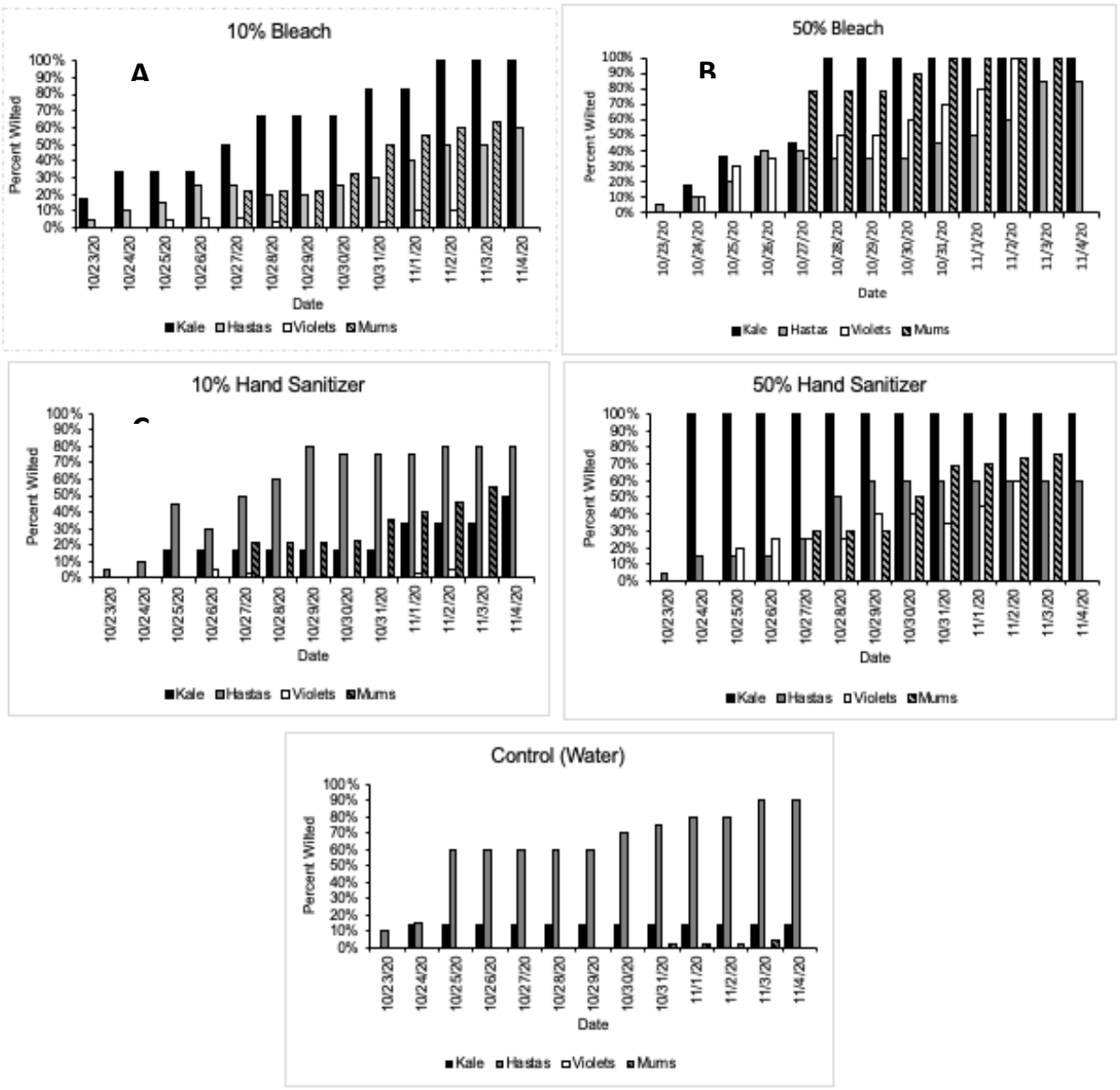

Figure 1. A) The death rate of kale, hostas, violets, and mums over a period of two weeks. Each plant was watered with a ratio of 10% bleach to 90% water. B) The death rate of each plant using a ratio of 50% bleach to 50% water. C) The death rate of each plant using a ratio of 10% sanitizer to 90% water. D) The death rate of each plant using a ratio of 50% sanitizer to 50% water. E) The death rate of each control plant over a period of two weeks.

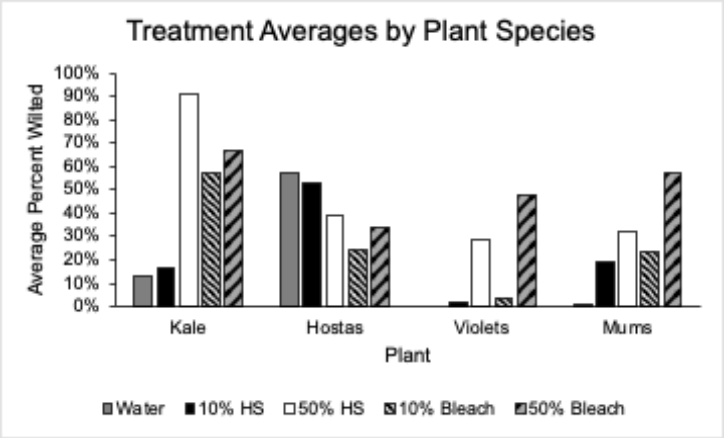

Figure 2. Average percent of plant wilted for each plant species and treatment.

DISCUSSION

Figure 3. The effects of bleach and hand sanitizer on garden mums.

We hypothesized that the simulated chemical runoff would have a negative effect on natural plant life. We focused on the two most common disinfectants being overused during the COVID-19 pandemic, hand sanitizer and bleach. We tested our hypothesis on four different sets of plants that we each treated individually. Although hand sanitizer did affect the plants, it did so at a slower rate than bleach. As expected, it was noted that the percentage of chemicals in our mixtures had a great impact on the rate of effect as well. Plants treated with a lower dosage of bleach and hand sanitizer showed detrimental effects throughout experimentation in most cases, but not to the same degree as those treated with a higher dosage of the chemicals. This is similar to a study performed by Jackman and Hughes (2010) on trihalomethanes (THMs) that were found in the soil and groundwater at sites where the release of organic solvents had occurred. Jackman and Hughes (2010) explain that THMs often contain sodium hypochlorite, otherwise commonly known as bleach. THMs may also contain chloroform, which is produced by mixing bleach and alcohol. Alcohol is the main ingredient in hand sanitizer and mixing it with bleach would cause a dangerous reaction. Chloroform is toxic when inhaled or comes into contact with the skin (Rai 2020). Therefore, THM's in soil would have a detrimental effect on the plants they come into contact with.

The fact that the chemicals affected the life span of the plants was expected as Ohoro et al. (2019) stressed that contamination in soil may lead to a build-up in plants. Additionally, they believe that this

concentration of chemicals may expose animals and humans through the ingestion of plant material. There has been an understanding amongst the public and scientists that the everyday products we use can have inadvertent and lasting effects other than their intended results. A 2012 study found that monitoring the contents and presence of pharmaceuticals in surface water is a viable way to track anthropogenic influence on the environment (Vystavna et al. 2012). This in essence proved our manipulations to be a good way of testing potential runoff effects on natural plant life.

One concern that arose while conducting our post analysis was the method in which each experimenter treated their plants. For instance, while we all used treatments composed of the same chemicals, and the same ratios of those chemicals, it should be noted that they were not exactly the same. Due to the manner in which we had to conduct our experiment, we had to perform our manipulations in different geographical areas. This made it difficult to obtain the same materials. Each experimenter used bleach of the same brand and concentration. However, the percentage of isopropyl alcohol varied slightly among the types of hand sanitizer used in each experiment. We all used a hand sanitizer with an isopropyl alcohol range from 60% to 80%. If we were to conduct the same experiment again, this is one parameter that we would change, in order to ensure our treatments were more consistent across each plant species.

Another concern we had was the location of our plants. Two experimenters kept and monitored their plants indoors, near sunlight, as directed for each respective species of plant. One experimenter kept and monitored their plants outside for a short period of the experiment, and then moved the plants indoors. One experimenter kept and monitored their plants outdoors for the duration of the experiment. Additionally, some plants are hardier than others such as the violets and garden mums. The Hosta control plant was close to death by the end of the experiment, possibly due to overwatering. These factors would be edited if we were to reconduct this experiment, to make sure that the results we obtained were not impacted by any outside variables we were not studying.

One interesting observation that was made during the course of this experiment was the impact bleach had on the soil. In the kale plants that were treated with bleach, the soil turned a yellow color, and the liquid that drained out of the bottom of the plants was black. It is likely that this was simply coloration of the soil being eroded by the bleach, however it could be indicative of a more serious impact to soil health and should be studied further if possible. Some factories that produce bleach are guilty of producing toxic chemical runoff such as a bleach kraft pulp mill. The bleaching process uses chlorine bleach which produces chlorophenol compounds that are discharged into the environment. These compounds are toxic environmental pollutants (Dominguez et al. 2002). We can theorize that other factories that produce chlorine bleach may also leak this toxic chemical into the soil and groundwater located near the site, harming the local flora and fauna. It is interesting to note that although chemical runoff due to COVID-19 negatively affects the environment, air pollution has decreased. Berman and Ebisu (2020) found that due to decreased vehicle and airline travel, our air quality has substantially improved. This finding is extremely important as exposure to poor air quality increases the risk of a COVID-19

Eventually, the COVID-19 pandemic will come to an end but the issue of contaminated soil in urban environments will continue. Approximately 55% of the world's population live in urban areas which is expected to increase. Urban soil is the most chemically contaminated soil and lacks fertility (Kumar et al. 2020). Fornal-Pieniak et al. (2019) stress that anthropogenic factors such as pollution, increasing temperature, and soil compaction all affect plant diversity. They believe it is imperative for urban areas to protect natural habitats as they maintain biodiversity (2019). Ganie et al. (2019) agree and stress that management interventions to conserve threatened species should be implemented after first assessing for operative threats. Regulations to control chemical runoff and other factors that affect the surrounding environment need to be created and enforced in order to protect natural plant life and the wildlife that depend on them.

CONCLUSIONS

Ultimately, the impacts of chemical runoff as a result of increased chemical use during the COVID-19 pandemic requires more research, especially since the pandemic is not over. Additionally, the likelihood of these chemicals entering the environment remains unknown, but possible. Further studies could look into the impacts of developing a new vaccine on the environment, as that is an incredibly complicated process requiring many different chemicals and materials that may accidentally end up in the environment.

Overall, our hypothesis was supported by the data, and the simulated chemical runoff had overall negative impacts on the plants. We were unable to study long term impacts as a result of our short time frame, which is why the concentrations were so high. Continuing to study the effects of common chemicals being used during the pandemic is incredibly important so that there are not unintended consequences to our environment. Additionally, the impacts of the chemicals on soil health may be important, as many odd and intriguing changes in the soil did occur.

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AUTHOR CONTRIBUTIONS

Conceptualization (all), Data Collection (all), Data Curation (all), Formal Analysis (ZM), Methodology (all), Project Administration (all), Resources (all), Visualization (all), Writing: Abstract (GG), Introduction (SB, GG), Methods (JZ), Results (ZM), Discussion (SB,GG), Conclusion (ZM), Acknowledgements (GG), Writing: review and editing (all)

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