ANALYSIS OF MERCURY CONCENTRATION IN A NORTHERN MICHIGAN BRYOPHYTE AND EDIBLE SURVEY

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ABSTRACT: Mercury (Hg) is a heavy metal and environmental pollutant associated with anthropogenic activity which may cause adverse health effects in top carnivores, including humans (Wolfe et al., 1998). The persistent nature of heavy metal pollutants in ecosystem soils has led researchers to pursue remediation strategies based on the uptake potential of plant and fungi species. Research detailing the efficacy of different plant species as bioremediators is limited, but there is some evidence to suggest that the bryophyte *Dicranum scoparium* is capable of absorbing and sequestering lead and other heavy metals (Garton & Rausch, 2019; Kondoh et al., 1998). The aim of this survey is to assess the mean Hg concentrations of bryophytes and wild foodstuffs found in dry and dry-mesic northern forests in Northern Michigan. I used linear regression to model the relationship between Hg concentrations in bryophytes and their proximity to anthropogenic activity with the additional context of soil characteristics, such as pH. I found that both soil pH and distance from man-made structures in the A and E Horizons are moderately and negatively correlated. The regression series describing *D. scoparium* found no strong correlations between Hg concentration and the explanatory variables. Moreover, the regression slopes for Hg concentration and each explanatory variable for *G. procumbens* and *V. angustifolia* vary closely around 0, which may be indicative of either no association between variables, or the presence of a constant upper limit of Hg absorption in these speciesAdditionally, ANOVA analysis revealed a statistically significant main effect of species on mean Hg concentration (*df*=2, 24, *F*=17.5627, *P*<0.0001), where *D. scoparium* had the greatest mean Hg concentration (mean=0.0483, SE=0.0094 µg/kg dry weight) and *V. angustifolium* had the least (mean=0.0012, SE=0.0004 µg/kg dry weight). These findings affirm that Hg concentrations of Northern Michigan edible foodstuffs *G. procumbens* and *V. angustifolia* fall within the safety limit of daily consumption for humans set forth by the EPA, and further support prior claims that *D. scoparium* is a bioremediator for contaminated soils.

Keywords: bryophyte, mercury, *Gaultheria procumbens*, *Dicranum scoparium*, *Vaccinium angustifolium*, Northern Michigan, bioremediator

INTRODUCTION

Mercury (Hg) is a heavy metal and environmental pollutant associated with anthropogenic activity which may cause adverse health effects in top carnivores, including humans. Mercury poisoning inhibits neurological, thyroid, and immune function and disrupts fetal development (Wolfe et al., 1998). The persistent nature of heavy metal pollutants in ecosystem soils has led researchers to pursue remediation strategies based on the uptake potential of plant and fungi species. Research detailing the efficacy of different plant species as bioremediators is limited, but there is some evidence to suggest that the bryophyte *Dicranum scoparium* is capable of absorbing and sequestering lead and other heavy metals (Garton & Rausch, 2019; Kondoh et al., 1998). The results of this study indicate that bryophyte sequestration of heavy metals could remove toxic contaminants from soils and reduce their availability for uptake by other plants. It is critical to develop knowledge on this remediation potential, especially in areas where humans and their foodstuffs live close to sources of toxic pollutants. In these cases, bioremediation would offer the unique benefit of reducing human exposure to heavy metals through contaminated foodstuffs.

This survey assesses baseline Hg concentrations in Northern Michigan bryophytes and wild foodstuffs found in dry and dry-mesic northern forests. I used linear regression to model the relationship between Hg concentrations in bryophytes and their proximity to anthropogenic activity with the additional context of soil characteristics, such as pH. The species of interest for this study are the bryophyte *D. scoparium*, and two commonly-found edibles from the Ericaceae (heath) family: *Gaultheria procumbens* (wintergreen) and *Vaccinium angustifolium* (lowbush blueberry). I expect that in more acidic soils, Hg will leach into soil horizons below root and rhizoid systems, resulting in lower Hg concentrations among all three species of interest. Additionally, I believe that *D. scoparium* will have the greatest mean Hg concentration due to its demonstrated potential to act as a bioremediator.

MATERIALS AND METHODS

Plant tissue samples were taken from the green shoots of *D. scoparium*, and the leaves, flowers, and berries (when available) of *G. procumbens,* and *V. angustifolium* from sites in Emmet, Cheboygan, Presque Isle, Kalkaska, and Crawford Counties across Michigan's Northern Lower Peninsula (NLP; n=26), and from Mackinac County in the Upper Peninsula (UP; n=1) during May of 2022. The plants were sampled opportunistically along roads and trails at each location. At the 14 collection sites, the pH of the soil was measured by retrieving a soil core with a stainless-steel soil sampling tube and using a LaMotte Soil pH Testing Kit with a duplex indicator (LaMotte Co., Chestertown, Maryland, USA). Plant tissue samples were found and collected at 11 of the 14 sites. The distance from the nearest human settlement (i.e. man-made structures such as paved roads and buildings) was calculated using the path function in Google Earth Pro (Keyhole Inc., Mountain View, California, USA) to connect the sample site coordinates to the point where the nearest man-made structure began.

Tissue samples were stored in paper envelopes for transport to the University of Michigan Biological Station (UMBS) laboratory where each sample was rinsed first with tap water, then with deionized water to remove external soil and debris (Garton & Rausch, 2019). The cleaned samples were oven-dried within 48 hours of collection until they reached a constant dry weight. Dried samples of *G. procumbens* and *V. angustifolium* were ground into a fine powder for analysis using a mortar and pestle that was sanitized between samples with water followed by an isopropanol rinse, and dried with a fresh Kimwipe (Kimberly-Clark Inc., Irving, Texas, USA). *D. scoparium* samples were homogenized with scissors while following the same sanitization procedures.

The Hg concentration (recorded as μg/kg dry weight) of plant tissue samples (6.696–51.986 mg) was determined using a Milestone DMA-80 Direct Mercury Analyzer (Milestone Inc., Shel-ton, Connecticut, USA; Witt et al., 2020). Each powdered sample was loaded into its own respective tray with a stainless-steel laboratory spatula.

Series of linear regressions were used to determine if there is a correlation between the concentration of Hg in the tissues of each species (response variable) and distance from the nearest human settlement, pH of soil Horizon A, and pH of soil Horizon E (explanatory variables); for these regression series, the dataset was refined to include data from only the 11 sites where tissue samples were collected. Linear regression was also used in describing the profile of all 14 sample sites to ascertain if there was a correlation between the response variables, pH of soil horizons A and E, with the explanatory variable distance from man-made structures. The strength of the relationship between Hg concentration and each of the explanatory variables was judged by the magnitude of Pearson's r correlation coefficient, and classified as strong ($0.666>r$), moderately strong ($0.666>r>0.333$), weak ($0.333>r>0.100$), or very weak ($r<0.100$). Additionally, the R^2 value was used to assess the "goodness of fit" of a simple linear model for the data and classified as being a good fit ($R^2>0.666$), moderate fit ($0.333<R^2<0.666$), and poor fit ($R^2<0.333$; Neter et al., 1996). I also calculated 95% confidence intervals (95% CI) for the slopes of all linear regressions to determine the uncertainty of each association. Lastly, a single-factor ANOVA test was used to determine if the mean Hg concentration of the samples varied by species with a significance level of $p<0.05$. I used Microsoft Excel 16.0 (Microsoft Corporation, Redmond, Washington, USA) for statistical analyses.

RESULTS

Site Profile and Combined Survey Results

TABLE 1. Summary statistics of raw data for the average Hg concentration in µg/kg dry weight and the standard error by each species of interest collected during May of 2022.

		Mercury Concentration (µg/kg, dry weight)	
Species	Number	Mean	Standard Error
Dicranum scoparium	10	0.0483	0.0094
Gaultheria procumbens	8	0.0116	0.0009
Vaccinium angustifolium	9	0.0011	0.0004

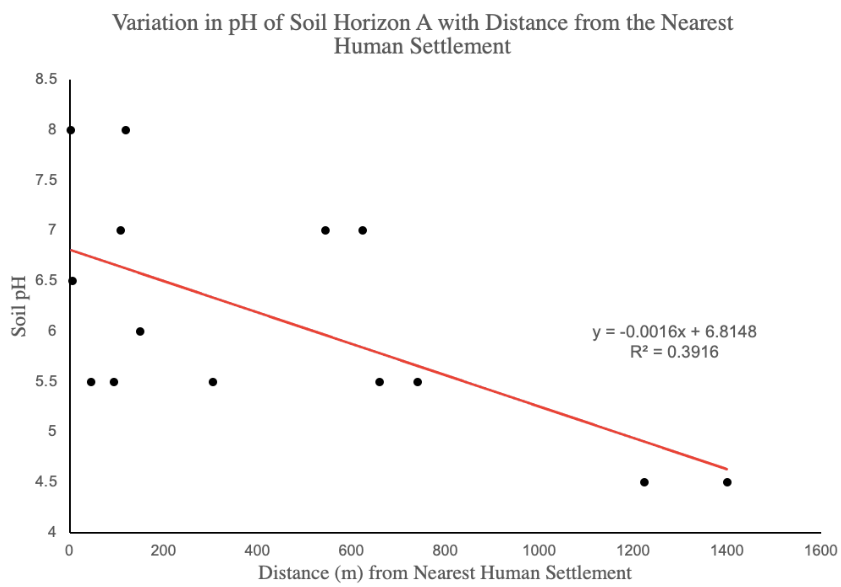

FIGURE 1. Regression line for the relationship between the pH of soil horizon A with the distance from the nearest paved road or building for sample sites (n=14) throughout Northern Michigan.

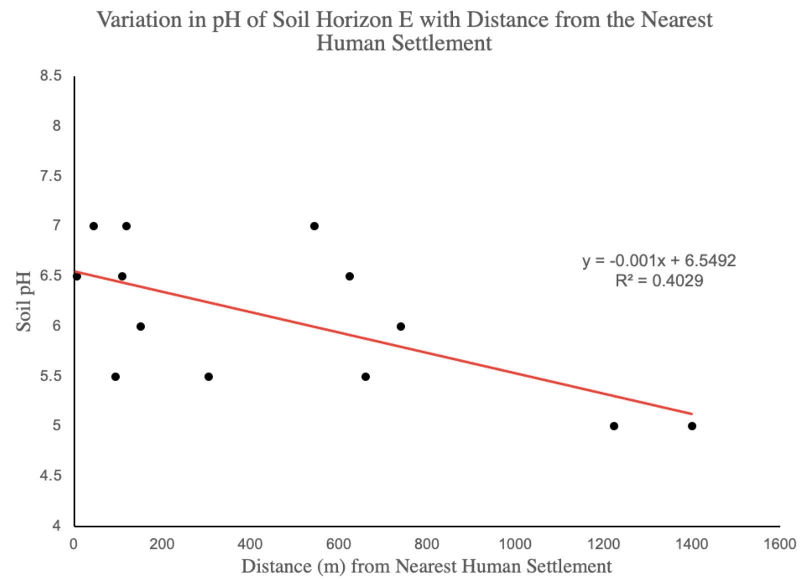

FIGURE 2. Regression lines for the relationship between the pH of soil horizon E with the distance from the nearest paved road or building for sample sites (*n*=14) throughout Northern Michigan.

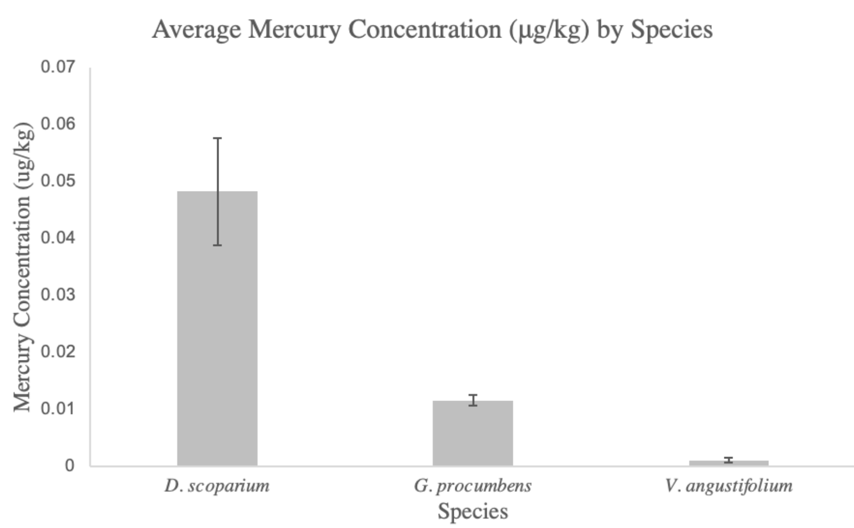

FIGURE 3. Bar chart of the mean mercury concentrations and standard error for each species, *D. scoparium*, *G. procumbens*, and *V. angustifolium,* in Northern Michigan.

For the 14 sites in northern Michigan where the pH of both soil horizons A and E were recorded, there is a moderately strong, negative, and linear relationship between soil pH and the distance from man-made structures in both the A Horizon (r=-0.6258, R^2=0.3916; 95% CI=[-0.0028, -0.0003]); Fig. 1) and E Horizon (r=-0.6347, R^2=0.4029; 95% CI=[-0.0018,

-0.0002]; Fig. 2) In both the A and E horizons, a linear model is moderately accurate fit for the data.

In the single-factor ANOVA analysis, I found a statistically significant main effect of species on mean Hg concentration (*df*=2, 24, *F*=17.5627, *p*<0.0001). *D. scoparium* had the greatest mean Hg concentration (*mean*=0.0483, *SE*=0.0094 µg/kg dry weight), while *G. procumbens* had the second greatest (*mean*=0.0116, *SE*=0.0009 µg/kg dry weight), and *V. angustifolium* had the least (*mean*=0.0012, *SE*=0.0004 µg/kg dry weight; Fig. 3).

Results for *D. scoparium* Regression Series

Among the *D. scoparium* samples, there was a weak negative linear correlation between Hg concentration and distance from human settlement (*r*=-0.2506, R^2=0.0628; 95% CI=[-0.0711, 0.0368]; Fig. A1), and a weak positive linear correlation between Hg concentration and the pH of the A soil horizon (*r*=0.1225, R^2=0.015; 95% CI=[-0.0215, 0.0291]; Fig. A2). A moderately strong, positive linear correlation was found between the Hg concentration and the pH of the E soil horizon (*r*=0.6725, R^2=0.4523; 95% CI=[0.0027, 0.0497]; Fig. A3). In this regression series, a linear model was a poor fit for both the relationship between Hg concentration and distance and the relationship between Hg concentration and A Horizon pH. However, the linear model was a moderate fit for the relationship between Hg concentration and E horizon pH.

Results for *G. procumbens* Regression Series

I found that in *G. procumbens*, there was a moderately strong positive linear correlation between both Hg concentration and distance from human settlement (*r*=0.5445, R^2=0.2965; 95% CI=[-0.0016, 0.0076]; Fig. B1). The linear correlation between Hg concentration and the pH of the A soil horizon was found to be weak and negative (*r*=-0.2638, R^2=0.0696; 95% CI=[-0.0031, 0.0018]; Fig. B2). Lastly, there was a moderately strong, negative correlation between Hg concentration and pH of the E soil horizon (*r*=-0.4298 R^2=0.1847; 95% CI=[-0.0049, 0.0025]; Fig. B3). The linear model was considered a poor fit for all three regressions in the series.

Results for *V. angustifolium* Regression Series

The linear relationships between Hg concentration and distance (*r*=0.0768, R^2=0.0059; 95% CI=[-0.0023, 0.0027]; Fig. C1), Hg concentration and pH of the E soil horizon (*r*=-0.0640, R^2=0.0041; 95% CI=[-0.0013, 0.0011]; Fig. C2), and Hg concentration and pH of the E soil horizon (*r*=0.0173 R^2=0.0003; 95% CI=[-0.0018, 0.0019]; Fig. C3) were all found to be very weak for the *V. angustifolium* regression series. Further, the linear model was a poor fit for all regressions in the series.

DISCUSSION

Analysis of Sample Site Profiles

Across all 14 sites where the pH of soil horizons A and E was sampled, there is a moderately strong, negative linear relationship between soil pH of both horizons and the distance from man-made structures; as distance increases, soil pH decreases and becomes more acidic (Fig. 1, Fig. 2). This claim is substantiated by both 95% CIs for slope falling within only negative values. This relationship cannot be determined to be causal without further analysis which was beyond the processing capabilities and time constraints of this study. However, this association may be explained by investigating the distribution of human settlements with high pH, alkaline soils.

It is possible that increasing pH with distance is related to selective building of settlements in regions with greater soil pH. Austrheim et al. (2005) demonstrated that plant biodiversity is positively related to soil pH, where greater species richness coincides with more alkaline soils. If alkaline soils can support greater species richness, it stands to reason that humans would preferentially inhabit alkaline regions where edible plant species may occur naturally in greater abundance, or where domestic crops are capable of producing greater yields. This notion is supported by the commonplace agricultural practice of "liming," in which the addition of lime to acidic soils artificially increases soil alkalinity (thereby decreasing pH) to increase crop health and yield (Goulding, 2016).

Analysis of *D. scoparium* Regression Series

Within *D. scoparium* samples, Hg concentration decreased with increased distance from human settlements. This finding is consistent with my expectation that Hg concentration would be greater at sites that are proximal to anthropogenic activity, likely due to spillover pollution from chemical and metal processing into nearby soils. The most common sources of Hg contamination are coal-burning power plants and mining operations, both of which have a history of occurrence in Michigan (Gworek, Dmuchowski, & Baczewska-Dąbrowska, 2020; Talberg, Scripps, & Philipps, 2019; National Minerals Information Center, 2017). However, this relationship was weakly correlated (r=-0.2506) and the 95% CI included 0 as a plausible value for the slope. Thus, it is possible that there is no relationship between Hg concentration and distance and as such, r alone does not offer compelling evidence that greater distance from paved roads and buildings is associated with decreased Hg concentration in *D. scoparium*.

When comparing the relationships of Hg concentration with A and E Horizon pH, the correlation between Hg concentration and A Horizon pH was weak with very little variation in Hg concentration explained by linear variation of A Horizon pH, and 0 falling within the 95% CI suggests that there may be no true correlation (r=0.1225, R^2=0.015; 95% CI=[-0.0215, 0.0291]; Fig. A2); whereas Hg concentration and E Horizon pH exhibited a moderate correlation, moderate fit along a linear model, and a 95% CI within a positive range (r=0.6725, R^2=0.4523; 95% CI=[0.0027, 0.0497] Fig. A3). These findings suggest that the Hg concentration found in *D. scoparium* tissues is more strongly related to the soil pH of the E Horizon than to the A Horizon. This relationship is curious because bryophytes lack a true root system that would reach the depth of an E Horizon. Instead, they are anchored to the surface layer of topsoils through root-like structures called rhizoids (Jones & Dolan, 2012). Generally, A horizons in forests exhibit greater acidity, which aids in the leaching of minerals, salts, and clays from the underlying E horizon (Natural Resources Conservation Service Wisconsin, 2022).

Analysis of *G. procumbens* Regression Series

Despite the poor fit of a linear model for all *G. procumbens* data, there remain patterns that may warrant further investigation. The strongest correlation for *G. procumbens* was found to be that of Hg concentration with explanatory variable distance (r=0.5445, R^2=0.2965; Fig. B1), but in the opposite direction that I expected. However, this trend may be spurious—the slope of the trendline varies closely with 0 (b=0.003; Fig. B1), which may be indicative of the presence of a constant upper limit of Hg absorption in *G. procumbens*. This idea is further supported by the similar slopes of the trendline describing variation in Hg concentration with A Horizon pH (b=-0.0007; Fig. B2) and the trendline describing variation in Hg concentration with E Horizon pH (b=-0.0004; Fig. B3). Additionally, all of the 95% CIs for *G. procumbens* straddle 0, which introduces the possibility of no actual relationship existing between the response and of the explanatory variables. Future studies should aim to establish whether there are true correlations between Hg concentration with distance and soil pH or a confidence interval to estimate the upper limit of Hg absorption in *G. procumbens* in Northern Michigan.

Analysis of *V. angustifolium* Regression Series

V. angustifolium exhibited very weak correlations (r_{C1}=0.0768, r_{C2}=-0.0640, r_{C3}=0.0173; Appendix C) between the explanatory and response variables and poor fits for linear models. The 95% CIs for slopes of the linear trendlines for *V. angustifolium* analysis all include and vary closely with 0 (b_{C1}=0.002, b_{C2}=-0.00009, b_{C3}=-0.00003; Appendix C). These findings suggest that there may be no correlation between Hg concentration and the explanatory variables distance, A Horizon pH, and E Horizon pH, and that there may be an upper limit for Hg absorption in *V. angustifolium* specimens in Northern Michigan.

The accuracy of the trendline estimate may have been compromised by the selection of sample sites for *V. angustifolium.* Out of the 9 samples collected, 4 were located on UMBS property, which is recognized as a part of the International Network of Biosphere Reserves. This designated status confers the responsibility of protecting samples of the world's major ecosystem types unto UMBS, and thereby reducing the impacts of anthropogenic activity and pollution on the biosphere (M'Bow, 1979). Three of these points that were located in a dry northern forest share a Hg concentration of 0.000 μg/kg dry weight, and a A Horizon pH of 5.5 (Appendix D). The fourth point was located in a dry-mesic northern forest in close proximity to a swamp. Due to their location on protected biosphere lands, the 3 identical data points could be influential in linear regression and ANOVA analyses, yet not truly representative of dry and dry-mesic forests in Michigan's NLP altogether. As for the fourth point which had a Hg concentration of 0.0023 μg/kg dry weight, future studies may reveal relationships between proximity to a wetland and Hg uptake, or higher levels of Hg in the underlying soil in swampy regions.

Analysis of ANOVA Output

TABLE 2. Measurements and calculations regarding the mean mercury concentration found in species of edible plants and their respective masses required to reach the dose of mercury regarded as safe for daily consumption.

Average Body Weight (lbs)	Average Body Weight (kg)	RfD (µg/kg body weight)	Mean Hg Concentration (µg/kg dry weight)		Edible Mass Required to Reach RfD (kg)	
			G. procumbens	*V. angustifolium*	*G. procumbens*	*V. angustifolium*
185.3	84.05	8.405	0.0116	0.0012	724.57	7004.17

In my single-factor ANOVA analysis, I found that mean Hg concentration varied significantly by species, with *D. scoparium* having the greatest mean Hg concentration and *V. angustifolium* the least (Fig. 3). This analysis has important implications for humans who forage casually or dependently for the edible species *G. procumbens* and *V. angustifolium*.

The U.S. Environmental Protection Agency (EPA) considers a reference dose (RfD) equal to the unit 0.1 µg/kg of body weight per day as the limit of “safe” levels of Hg consumption (EPA, 2000). This RfD is orders of magnitude larger than the mean Hg concentrations found in foodstuffs *G. procumbens* and *V. angustifolium.* An average American weighing 185.30 lbs (84.05 kg) would need to consume approximately 724.57 kg of *G. procumbens* or 7004.17 kg of *V. angustifolium* to reach their daily RfD of 8.405 µg (Table 2; Fryar et al., 2021). Consumption of *G. procumbens* and *V. angustifolium* realistically falls far below these thresholds, thus rendering both species safe for human consumption in Northern Michigan. By extension, as both species share classification within the heath family Ericaceae, other edible heaths found in Northern Michigan may have similarly low Hg concentrations, though further study should be conducted to ensure safety of consumption.

While *D. scoparium* is not utilized by humans as a foodstuff, the results of my ANOVA do support its potential as a viable bioremediator. Prior research has identified *D. scoparium* as naturally sequestering lead from its environment in its tissues and uptaking Hg^{2+} from solution (Garton & Rausch, 2019; Kondoh et al., 1998). If *D. scoparium* were not more capable of Hg absorption, I would expect there to be no difference in mean Hg concentration between *G. procumbens* and *V. angustifolium*. However, the mean Hg concentration of my *D. scoparium* samples was significantly greater than both species, despite having been collected at the same sample sites. Because of this difference, I have evidence to suggest that *D. scoparium* preferentially sequesters Hg compared to the wild foodstuffs *G. procumbens* and *V. angustifolium.* Thus, *D. scoparium* can still be considered for further use as a bioremediator, including in areas where humans consume wild foodstuffs.

CONCLUSION

I found that soil pH and distance from man-made structures in both the A and E Horizons (Fig. 1, Fig. 2) are moderately and negatively correlated. This association may be due to humans preferentially settling in alkaline regions where edible plant species occur naturally in greater abundance and domestic crops are capable of producing greater yields. The regression series describing *D. scoparium* found no strong correlations between explanatory and response variables. Additionally, no strong correlations were found between the explanatory and response variables in the regression series for both *G. procumbens* and *V. angustifolium.* Moreover, the slopes of the regression trendlines for Hg concentration and each explanatory variable for *G. procumbens* and *V. angustifolia* vary closely around 0, which may be indicative of either no association between variables, or the presence of a constant upper limit of Hg absorption in these species. Additionally, through the use of ANOVA analysis, I found that mean Hg concentration varied by species, where *D. scoparium* had the greatest mean Hg concentration and *V. angustifolium* the least. These findings support the work of prior studies that presented *D. scoparium* as a potential bioremediator for contaminated soils. Further, they establish that the Hg concentrations of Northern Michigan edible foodstuffs *G. procumbens* and *V. angustifolia* fall within the safety limit of daily Hg consumption for humans set forth by the EPA.

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APPENDIX A: Descriptive Figures for *Dicranum scoparium* Analysis

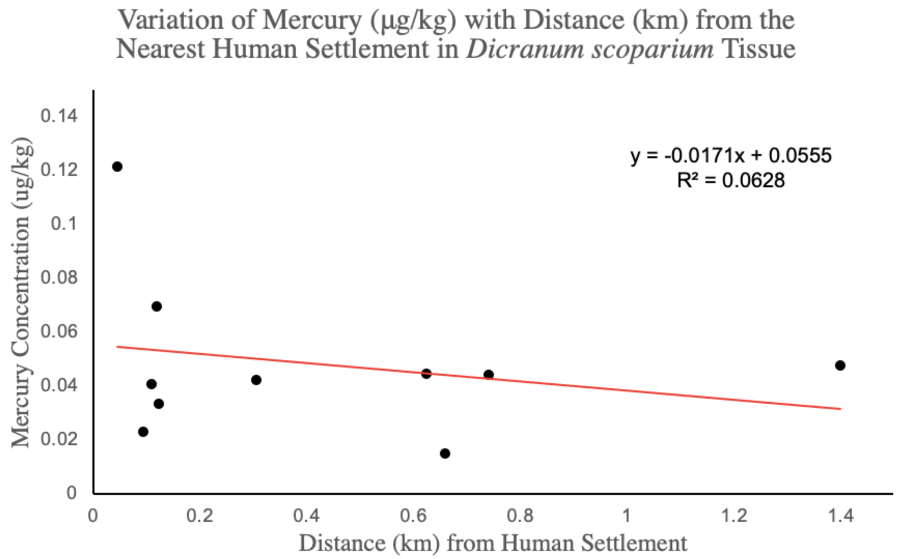

FIGURE A1. Regression line for the relationship between mercury concentration in µg/kg dry weight with distance from the nearest paved road or building for *D. scoparium* collected in Northern Michigan in May 2022.

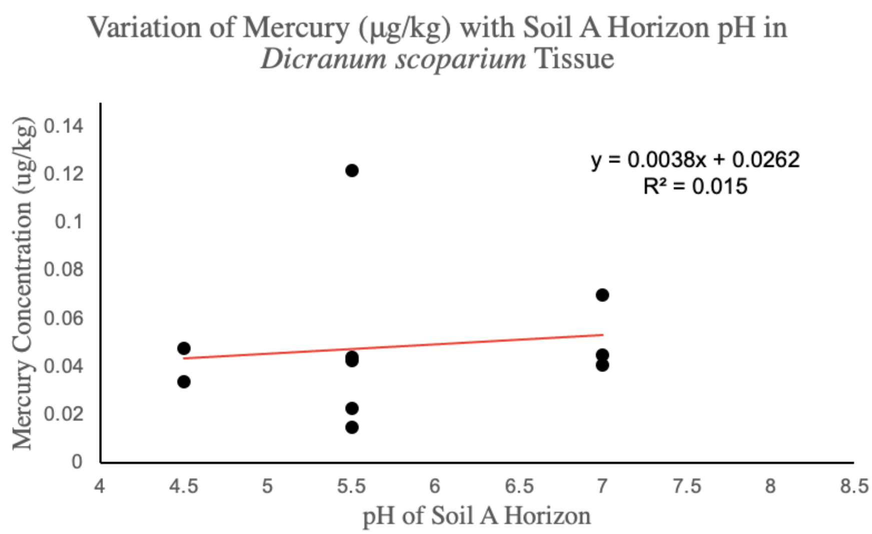

FIGURE A2. Regression line for the relationship between mercury concentration in µg/kg dry weight with pH of the A soil horizon for *D. scoparium* samples collected in Northern Michigan in May 2022.

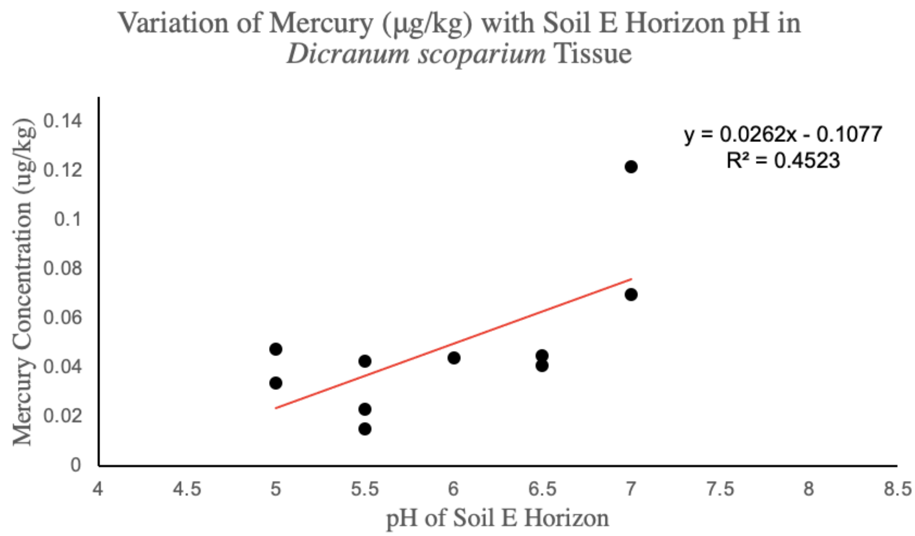

FIGURE A3. Regression line for the relationship between mercury concentration in µg/kg dry weight with pH of the E soil horizon for *D. scoparium* samples collected in Northern Michigan in May 2022.

APPENDIX B: Descriptive Figures for *Gaultheria procumbens* Analysis

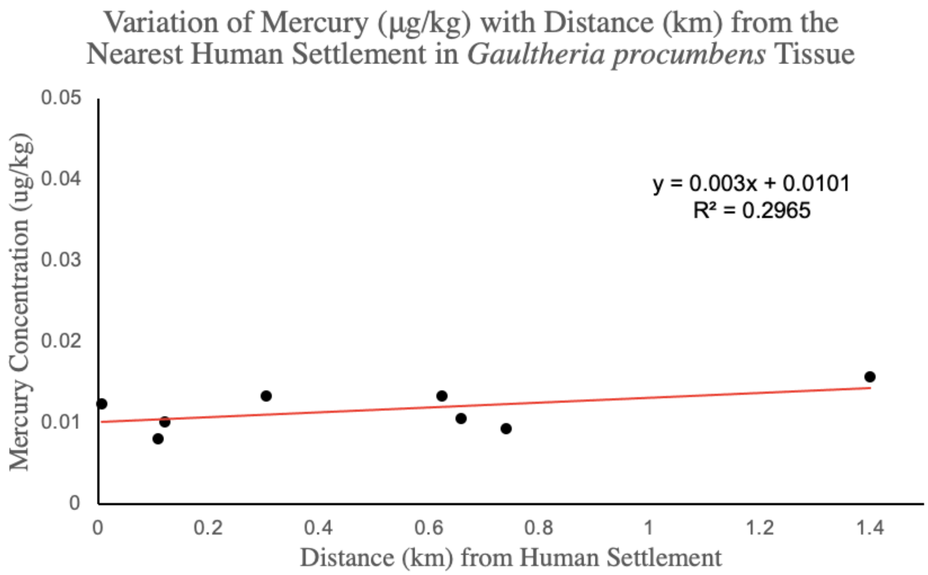

FIGURE B1. Regression line for the relationship between mercury concentration in µg/kg dry weight with distance from the nearest paved road or building for *D. scoparium* collected in Michigan's Northern Lower Peninsula in May 2022.

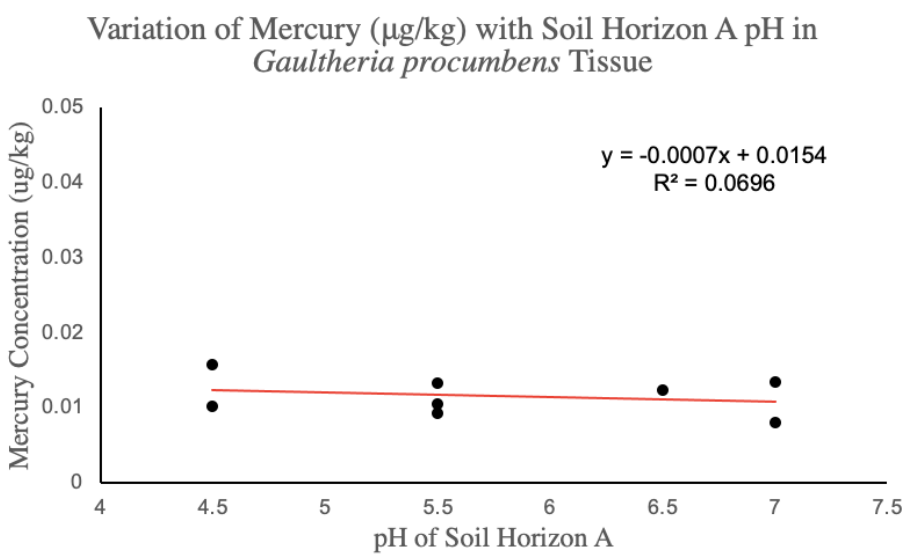

FIGURE B2. Regression line for the relationship between mercury concentration in µg/kg dry weight with pH of the A soil horizon for *G. procumbens* samples collected in Michigan's Northern Lower Peninsula in May 2022.

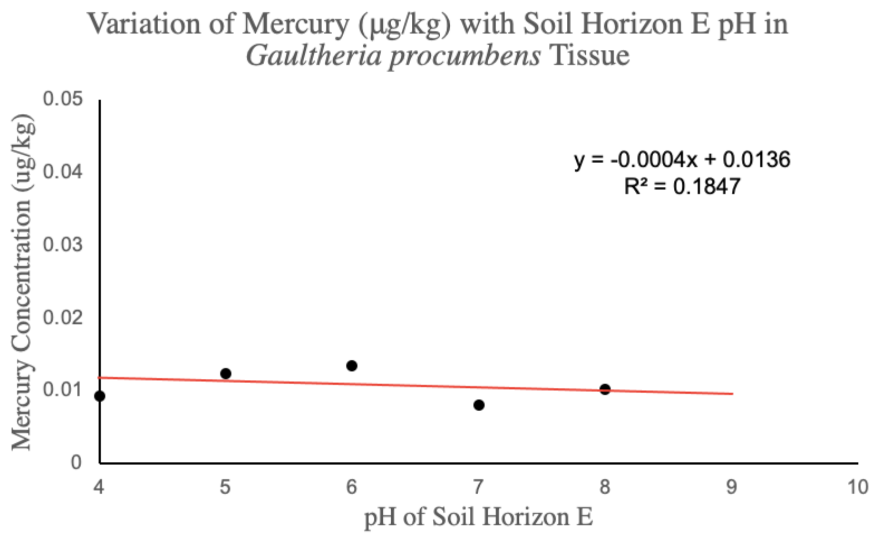

FIGURE B3. Regression line for the relationship between mercury concentration in µg/kg dry weight with pH of the E soil horizon for *G. procumbens* samples collected in Michigan's Northern Lower Peninsula in May 2022.

APPENDIX C: Descriptive Figures for *Vaccinium angustifolium* Analysis

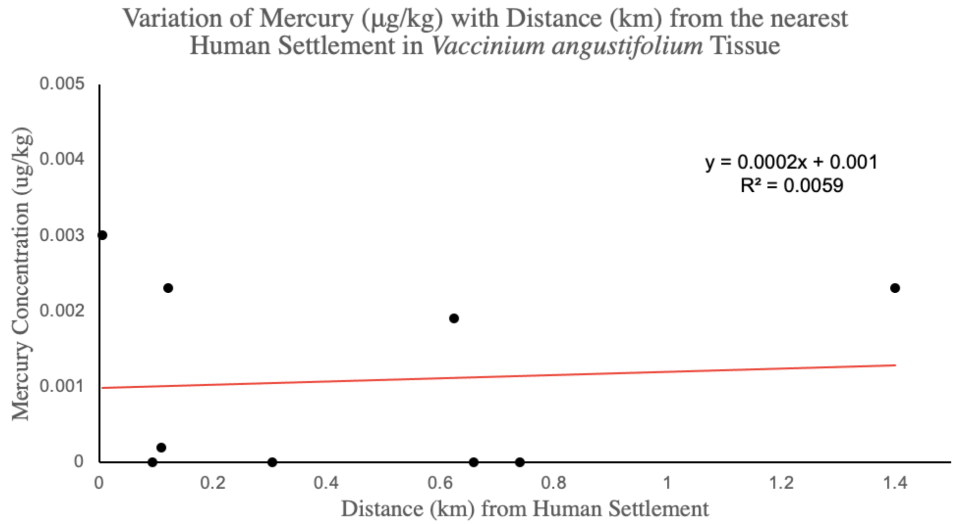

FIGURE C1. Regression line for the relationship between mercury concentration in µg/kg dry weight with distance from the nearest paved road or building for *V. angustifolium* collected in Michigan's Northern Lower Peninsula in May 2022.

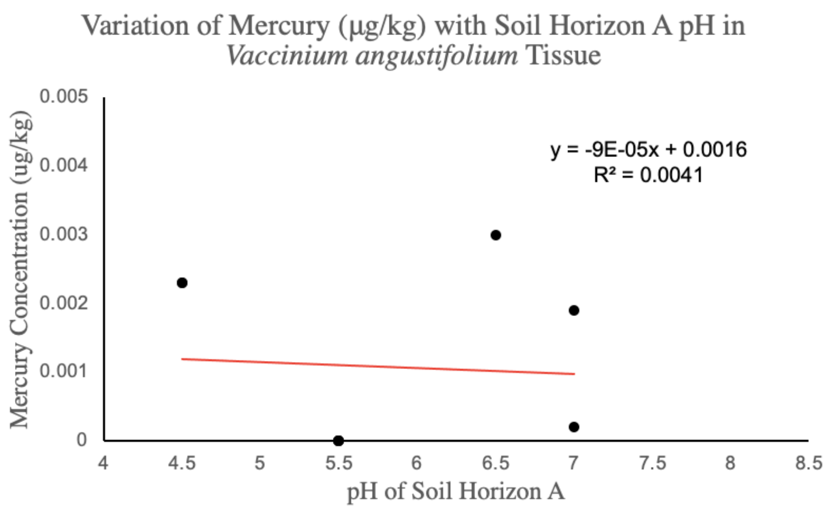

FIGURE C2. Regression line for the relationship between mercury concentration in µg/kg dry weight with pH of the A soil horizon for *V. angustifolium* samples collected in Michigan's Northern Lower Peninsula in May 2022.

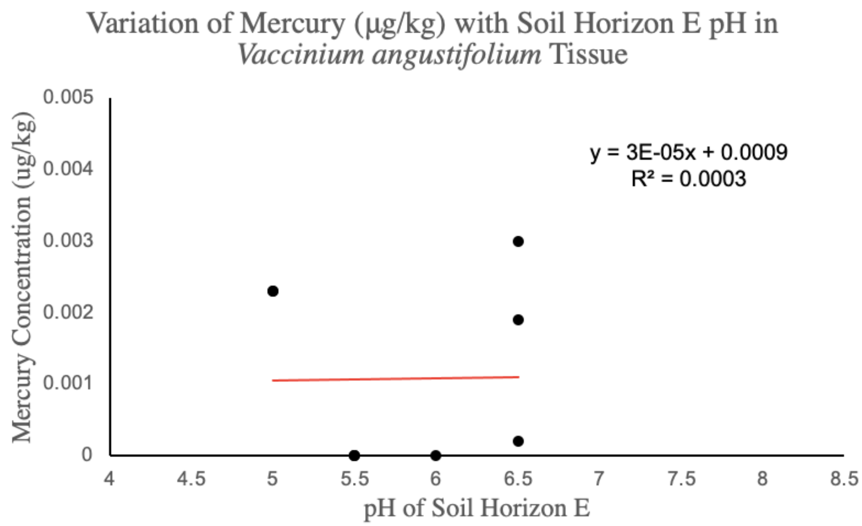

FIGURE C3. Regression line for the relationship between mercury concentration in µg/kg dry weight with pH of the E soil horizon for *V. angustifolium* samples collected in Michigan's Northern Lower Peninsula in May 2022.

APPENDIX D: Raw Data of Samples Categorized by Species

TABLE D1. Raw data including county of collection, distance from the nearest human settlement, pH of soil horizons A and E, and mercury concentration for all samples collected in Michigan's UP and NLP during May 2022, categorized by species. Samples collected on UMBS property are delineated in red.

	Dicranum scoparium					*Gaultheria procumbens*					*Vaccinium angustifolium*				
#	County	Distance (km)	A pH	E pH	Hg (µg/kg)	County	Distance (km)	A pH	E pH	Hg (µg/kg)	County	Distance (km)	A pH	E pH	Hg (µg/kg)
1	Cheboygan	0.659	5.5	5.5	0.0149	Cheboygan	0.659	5.5	5.5	0.0105	Cheboygan	0.659	5.5	5.5	0.000
2	Cheboygan	1.400	4.5	5	0.0476	Cheboygan	1.400	4.5	5	0.0157	Cheboygan	1.400	4.5	5	0.0023
3	Cheboygan	0.305	5.5	5.5	0.0425	Cheboygan	0.305	5.5	5.5	0.0133	Cheboygan	0.305	5.5	5.5	0.000
4	Cheboygan	0.740	5.5	6	0.0441	Cheboygan	0.740	5.5	6	0.0093	Cheboygan	0.740	5.5	6	0.000
5	Emmet	0.624	7	6.5	0.0447	Emmet	0.006	6.5	6.5	0.0123	Emmet	0.006	6.5	6.5	0.003
6	Presque Isle	0.119	7	7	0.0698	Emmet	0.624	7	6.5	0.0134	Emmet	0.624	7	6.5	0.0019
7	Kalkaska	0.109	7	6.5	0.0408	Kalkaska	0.109	7	6.5	0.008	Kalkaska	0.109	7	6.5	0.0002
8	Crawford	0.094	5.5	5.5	0.0229	Cheboygan	1.224	4.5	5	0.0102	Crawford	0.094	5.5	5.5	0.000
9	Mackinac	0.045	5.5	7	0.1216						Cheboygan	1.224	4.5	5	0.0023
10	Cheboygan	1.224	4.5	5	0.0336										