The Effect of The Amount of Water and Water Exposure Time on the Absorbency of Sponges

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INTRODUCTION

Given the current global pandemic, now more than ever it is important to understand what factors lead to the best absorbency in a sponge as to stop the spread of bacteria and germs. The purpose of the experiment will be to determine the effect of the amount of time (15 seconds, 30 seconds, 45 seconds, 60 seconds, 75 seconds, and 90 seconds) and the amount of water (24 ounces, 32 ounces, and 40 ounces) on the absorbency of a sponge.

- Null Hypothesis: There is not an interaction between the amount of water and the amount of time on the absorbency in a sponge.
- Alternative Hypothesis: There is an interaction between the amount of water and the amount of time on the absorbency in a sponge

METHODS

Independent Variable: The Type of Sponge and the Amount of Time in the Water
Dependent Variable/Response Variable: The amount of water in ounces that remains in the bowl after the sponge has been removed.

To begin, a sponge will be placed in a bowl with 4 ounces of water and left for 15 seconds. After 15 seconds, the sponge will be removed and the amount of water remaining in the bowl will be measured, subtracted from the original amount of water, and recorded. The bowl will be dried, and the same process will be repeated, but the amount of time will change to 30 seconds, 45 seconds, 60 seconds, 75 seconds, and 90 seconds. Next, a sponge will be placed in a bowl with 8 ounces of water and left 15 seconds. After 15 seconds, the sponge will be removed and the amount of water remaining in the bowl will be measured, subtracted from the original amount of water, and recorded. The bowl will be dried, and the same process will be repeated, but the amount of time will change to 30 seconds, 45 seconds, 60 seconds, 75 seconds, and 90 seconds. Then a sponge will be placed in a bowl with 12 ounces of water and left for 15 seconds. After 15 seconds, the sponge will be removed and the amount of water remaining in the bowl will be measured, subtracted from the original amount of water, and recorded. The bowl will be dried, and the same process will be repeated, but the amount of time will change to 30 seconds, 45 seconds, 60 seconds, 75 seconds, and 90 seconds.

PROPOSED ANALYSIS

After the data is recorded, R Studio will be used to run the analysis of the factorial design. An alpha value of 0.05 will be used because it is the industry standard and it is not too liberal, or too conservative. An ANOVA test will be used to determine if there is an interaction between the amount of water in the bowl and the amount of time that the sponge is in the water and the amount of water absorbed by the sponge.

Before beginning the analysis, the assumptions of an ANOVA test will be checked. The assumptions of an ANOVA test are Independence, Normality, and Homogeneity of Variance. As a new sponge was used for every trial, the only thing relating the data is the bowl, but the bowls were dried before each new measurement. Since there is no other evidence of related data, the independence assumption is passed.

The normality assumption will be tested by looking at a qqplot as well as the Shapiro-Wilkes test. If the p-value in the output of the Shapiro-Wilkes test is less than our alpha value (0.05) then there is a violation and the data is not normally distributed. If there is a violation, then it would be inappropriate to continue.

The Homogeneity of Variance assumption will be tested by looking at a boxplot of the data and by using the Breusch Pagan test. If the p-value in the output of the Breusch Pagan test is less than our alpha value (0.05) then there is a violation and the data does not exemplify equal variance. If there is a violation, then it would be inappropriate to continue.

After assumptions are passed, the analysis of the data can begin. If the p-value of the ANOVA test is below our alpha value of 0.05, then we reject the null the null hypothesis and conclude that there is no interaction. If there is an interaction, it would be inappropriate to analyze the individual effects. If the p-value is above the 0.05 alpha value, then we fail to reject the null hypothesis and conclude that there is not an interaction. When there is not an interaction, it is appropriate to analyze the individual effects.

TRANSFORMATION

After checking the normality assumption, it is appropriate to conclude that the normality assumption is passed. Looking at the graphs, there was only a bit of deviation from the normality line. The results of the Shapiro-Wilkes Test allow the conclusion that the normality assumption is passed because it computed a p-value of 0.3338, which is greater than our set alpha value of 0.05, which means we fail to reject the null hypothesis and conclude that there is not a violation of normality. Because of the results of the test and the small amount of deviation from the normality line, it is appropriate to conclude that they normality assumption is passed.

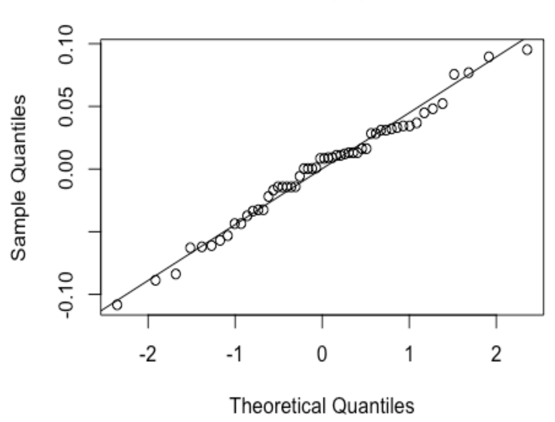
After checking the equal variance assumption, it is appropriate to conclude that the data does not exemplify equal variance and therefore, the assumption is violation. Looking at the plots, there was a concerning "horizontal V-like" pattern in the data. The boxplot of the absorbency and the water does not look great and the boxplot of the absorbency and the time looks just ok. The results of the Breusch Pagan test allow the conclusion that the equal variance assumption is not passed because it computed a p-value of 0.03879, which is less than our set alpha value of 0.05, which means we reject the null hypothesis and conclude that there is a violation of equal variance. The results of the residual plot, the boxplots and the Breusch Pagan test, make it appropriate to conclude that the equal variance assumption is violated.

Because the equal variance assumption failed, a transformation is necessary. A log transformation of the dependent variable will be used to create a new model that passes assumptions. After creating a new model with the absorbency variable computed to a log transformation, the assumptions must be checked again.

RESULTS

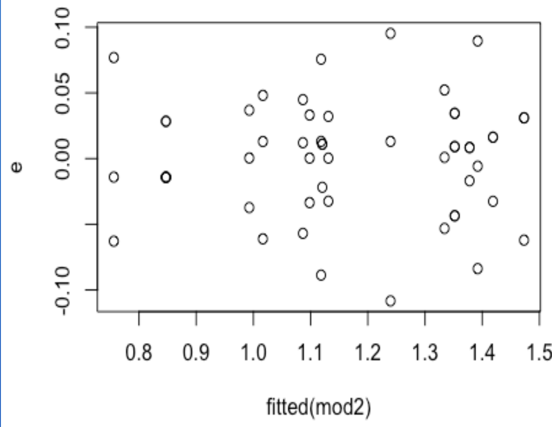
Looking at Graphic A below, there is a bit less deviation from the normality line. The residual points are a bit closer to the line then they were before. The results of the Shapiro Test yield a p-value of 0.6251, which is greater than out alpha value of 0.05. Based on the results of the tests and the graphs, it is appropriate to pass the normality assumption.

Graphic A: Normality Plot

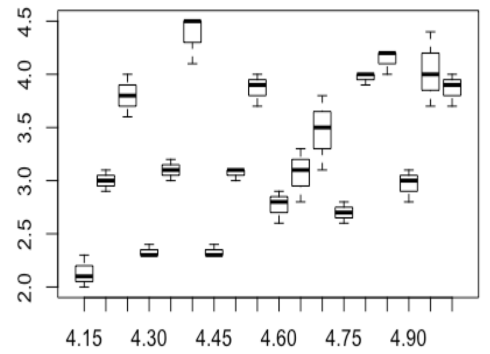


Looking at Graphic B below, it is apparent that no real pattern exists. The "horizontal V-shape" that existed before is not as recognizable. The boxplots in Graphic C and Graphic D also look a little bit better. The plot in Graphic C looks just ok. When the water is at 4 ounces and 12 ounces, the boxplots look very similar, but when the water is at 8 ounces, the variance changes. Graphic D also looks just ok. At 60 and 75 seconds, the boxplots look different than the others. Looking at Graphic E, there are a few box and whiskers that do not show equal variance. The results of the Breusch Pagan test allow the conclusion that the equal variance assumption is passed because it computed a p-value of 0.05956, which is greater than our set alpha value of 0.05, which means we fail to reject the null hypothesis and conclude that there is not a violation of equal variance. The results of both residual plot and the Breusch Pagan test, make it appropriate to conclude that the equal variance assumption is passed, and the analysis can now be done.

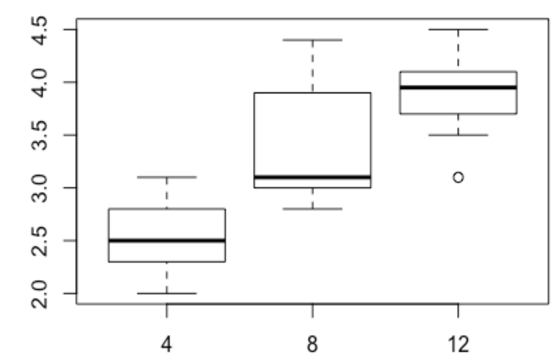
Graphic B: Equal Variance



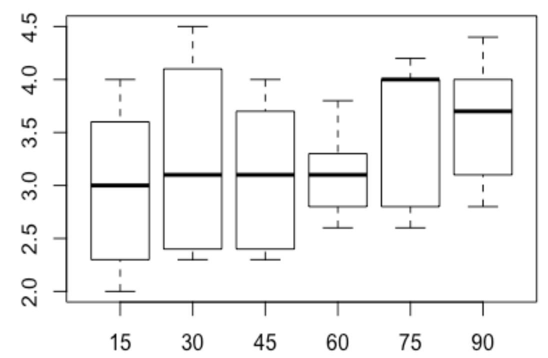
Graphic E: Equal Variance



Graphic C: Absorbency Vs. Water



Graphic D: Absorbency Vs. Water

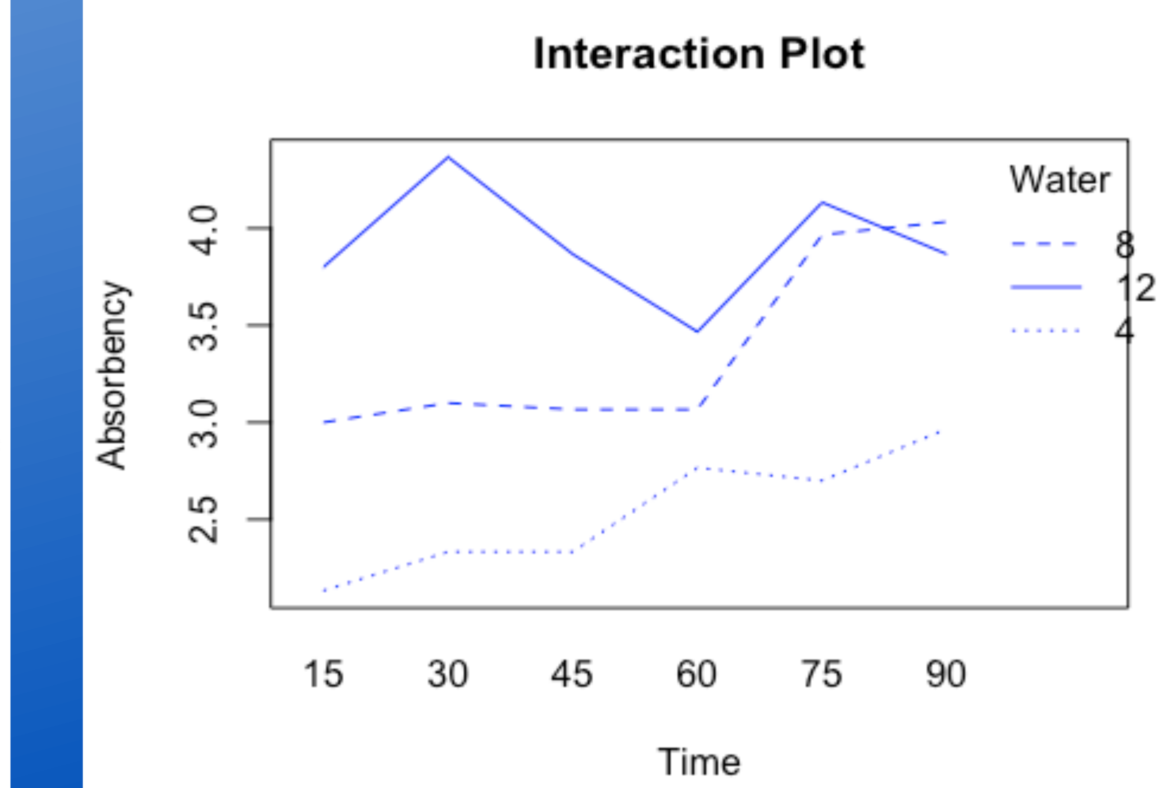


See Table 1 to the right for a breakdown of the ANOVA table. The p-value for the interaction between time and water on the absorbency of a sponge is nearly 0, which is less than our set alpha value of 0.05. Because of this, we reject the null hypothesis and conclude that there is an interaction between the time that the sponge was in the water and the amount of water in the bowl on the absorbency of the sponge at the alpha=.05 level. Because the interaction is statistically significant, it is inappropriate to analyze the individual factors.

CONCLUSIONS

By looking at the interaction plot you can see that 12 ounces of water and 30 seconds in the water yields the highest amount of water absorbed. With 4 ounces of water in the bowl, the more time that the sponge spends in the water, roughly the more water is absorbed. The same is true for using 8 ounces of water, but it makes a large jump after the sponge was left in the water for over 60 seconds and then tapers off. A sponge in 12 ounces of water for nearly 80 seconds and a sponge in 8 ounces of water for nearly 80 seconds has the same effect on absorbency. Although it seems like a sponge in 12 ounces of water is the optimal amount, when a sponge is left in the water for 90 seconds, 8 ounces of water records higher absorbency.

Graphic E: Interaction Plot



REFERENCES

- R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R- project.org/.
- Montgomery, Douglas C. *Design and Analysis of Experiments*. Wiley, 2017.

Table 1: ANOVA Table

	Degrees of Freedom	Sum of Squares	Mean of Squares	F	P
Water	2	17.335	8.667	270.543	0
Time	5	3.419	0.684	21.342	0
Interaction	10	3.092	0.309	9.651	0