TED ANKARA COLLEGE FOUNDATION HIGH SCHOOL

Comparing the Bactericidal Effect of Varying NH_3 and Chlorinated Water solutions on the *Number of colonies of Microorganisms* which we interact with in our daily lives

Extended Essay

Biology

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ABSTRACT

It is an inevitable event for every human being not to interact with environment. As a result of this fact, people always contact with microorganism involuntarily in their daily lives and touching a single object is quite enough to let the microorganisms move through the object and contact our skin. In that case, the common materials like cell phones, money, keyboards and door handles are the greatest sources of the harmful bacteria we met in our daily lives. Therefore, the objective of this study was to investigate whether NH_3 can be used as an alternative cleaning substance instead of chlorinated water. To make a fair and realistic comparison, different concentrations (5%, 10% and 15%) of each cleaning substance is taken into consideration.

In order to compare the efficiencies of NH3 and chlorinated water, amount of colony formed bacteria eliminated by different cleaning substances were counted. Keyboards are the common tools which were used as the sources of bacteria. Some statistical analysis had been done to reach results of our experiment. T- test results revealed that there wasn't a significant mean difference between the cleaning agents in terms of their bactericidal effects. In other words, it was found that NH_3 and chlorinated water are equally effective on harmful bacteria. Moreover, according to the results of ANOVA, the experiment also showed that increasing the concentration of NH_3 and chlorinated water doesn't influence their effectiveness. Although NH_3 seems more effective when 10% concentrations of NH_3 and chlorinated water are compared, it couldn't be statistically justified.

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INTRODUCTION

In our daily lives human beings use lots of common materials such as money, cell phones, computers, door handles and credit cards. Moreover, human beings generally can take a place in common areas like stations, houses and markets which are totally available for microorganisms to settle in lots of human bodies. According to Dr. Christine Zurawski, M.D., germs [both viruses and bacteria] are part of our everyday lives.[1] I observed that these microorganisms which are in an interaction among the humans can be harmful and cause infectious diseases. As we know that there are lots of diseases for example plague spread and caused the death of high amount of people in human history. Some of these plagues' transmission is caused by interaction between people. The usage of common materials among people is one of the fundamental facts which cause the interaction between humans and the spread of harmful microorganisms.

The first time, I encountered the topic in which this extended essay focuses on happened during a conversation. I was told that the reason of my seasonal flu could be the use of materials that are used by other people as well. As an evidence of this theory, are the facts that, I had shared my laptop with lots of people recent days and the statement "Dr. Randy Martin: Germs are everywhere – in fact, there could be thousands on your keyboard and even on your cell phone".[2] also supports my idea. In other words, the harmful microorganisms probably spread around and transferred to me through my keyboard. I got very surprised as I became sick because of a very simple daily life routine. As a result of this, I began to research this issue.

Results of my research showed that staphylococcus, pseudomonas and proteus are the microorganisms which have the highest probability of existence in common materials used by

[1] *http://healthwatchmd.com/2011/11/germs-the-good-the-bad-the-ugly/*

[2] *http://healthwatchmd.com/2011/11/germs-the-good-the-bad-the-ugly/*

people. Also some fungi can be found. These harmful microorganisms are the most popular ones which have the highest quality of being used in the experiment.

A *staphylococcus* is a bacterium in the Staphylococcus genus, a very common bacterial genus which is very widely distributed throughout the world, making it a familiar sight in doctors' offices, medical centers and labs. In fact, you are hosting a few Staphylococcus bacterium right this very minute, because these bacterium are part of the body's natural bacterial fauna. The most famous Staphylococcus species is probably *S. aureus*, the bacterium which is responsible for the staph infections which plague people for ages. [3]

Pseudomonas bacteria are any bacteria of the Pseudomonas genus of gamma proteobacteria. This type of bacteria is often infectious and has many common properties with the other pathogenic bacterium. They occur very commonly in water and some types of plant seeds. For this reason, they were observed very early in the history of microbiology. Furthermore, the name Pseudomonas literally means "false unit." [4]

Proteus mirabilis is a rod shaped bacteria. This rod shaped bacteria has the ability to produce high levels of urea. Urease hydrolyzes urea to ammonia and thus makes the urine more alkaline. If this disease has been untreated more, the increased alkalinity can crystallize to calcium carbonate or apatite. The bacteria can be found throughout the stones, and these bacteria lurking in these stones can reinitiate infection after antibiotic treatment.[5]

There are several ways to stop this interaction by using specific chemicals which totally destroy harmful microorganisms or prevents them from reproduction and diffusion or remove

[3] http://www.wisegeek.com/what-is-staphylococcus-bacteria.htm

[4] http://www.wisegeek.com/what-is-pseudomonas-bacteria.htm

[5] http://en.wikipedia.org/wiki/Proteus_mirabilis

them completely from the skin. Liquid detergent and liquid soap can be specified as the substances that are highly effective on harmful microorganisms.

To sum up, in this experiment my aim is to determine the common areas where harmful microorganisms exist, live and find the best way to avoid the spread of them. I decide to achieve my goal by testing the different chemical substances on specific types of the harmful microorganisms which we interact with and finding out the most effective chemical substance on this specific bacterium. Therefore, my research question is "How do the increasing concentrations of NH3 solution and chlorinated water affect the number of colonies of bacteria (Staphylococcus, Pseudomonas, Proteus mirabilis) obtained from keyboards destroyed in constant temperature and which one of these cleaning substances is more effective?"

HYPOTHESIS

According to the researches done in modern age, it is certainly predicted that chlorinated water is the best way to get rid of these harmful bacteria. Though, if you use chlorinated water as most of us do, you have a significantly increased chance (93%) of getting cancer. So there must be a chemical substance found which is effective as chlorinated water and harmless to human beings. In addition to this, I assume that NH3 (ammonia) solution is also highly effective on harmful bacteria. NH3 solution may become the chemical which can totally fix that problem. Therefore, my research question is "How do the increasing concentrations of NH3 solution and chlorinated water affect the number of colonies of bacteria (Staphylococcus, Pseudomonas, Proteus mirabilis) destroyed in constant temperature and which one of these cleaning substances is more effective.

It can therefore be hypothesized as; "The cleaning substance which contains NH3 solution is more effective than chlorinated water on harmful microorganisms which we interact with in our daily lives."

METHOD DEVELOPMENT AND PLANNING

Designing an appropriate method in order to support or reject the proposed hypothesis and answer the given research question brought various problems with it. One of them was how to collect the organisms into a sterilized place and to obtain it in a form which would make it available for investigation. We have agars swabs for this process, which is a little folder containing agar nutrients to keep the organisms alive, and a stick with cotton. There are two main functions of this material; collecting bacteria in the cotton-tip, preventing the collected bacteria from interacting with environment until they reach the laboratory and undergo another step.

Measuring the number of collected organisms is the most important step of our experiment which will allow us to compare the effectiveness of two cleaning substances. As a result, how to count the number of bacterium was a serious issue. Without being able to determine this accurately, we can't make any quantitative analysis about the validities of two different cleaning substances. After some further research, the problem could finally be solved by performing a specific method called spread plate which includes blood agar and Petri dishes. In this method, firstly we locate the bacteria collected from one of the samples into a Petri dish by spreading the microorganisms in the cotton-tip of the agar swab. Approximately 75% of these Petri dishes must be filled by bloody agar which contains vital nutrients in order to provide the reproduction process of the bacteria. Next, we incubate the bacteria in an oven for 24 hours which is a substantially sufficient period for them to reproduce. Basically, in this method we are able to count the number of collected bacteria. I also tried whether it is applicable or not. The results showed that it is probably the best way to measure the number of organisms. Besides, we also have to identify the type of collected bacteria. In this stage, we used an automated bacterial identification device called VITEK2 which can only be found in a laboratory.

As we said that, in our experiment we compare the effects of two different cleaning substances on harmful organisms which we encounter in our daily lives. Therefore, we had to take samples from a tool we usually used, then we decided that keyboards are the most

suitable tools for this process because keyboards collect lots of bacteria from environment through our hands.

Now it became important to make sure that all controlled variables were maintained. Temperature, humidity, pressure and light intensity are the most apparent of these variables. First of all, it was decided to perform the collecting process in a room without windows to keep temperature as much as possible. To make all keyboards receive the same amount of light we put some extra bulbs (40 Watt). We don't have to make extra preparations to prevent the effect of humidity and pressure although it is another important issue. All of the keyboards were taken from the same place and the samples were collected in my home and counted in a laboratory .In other words, all the samples are found in the same places. As long as all bacteria are under the same condition in terms of humidity and pressure, they don't affect our data. After making sure that humidity and pressure aren't effective, we are able to make all variables remain constant through the experiment. On the other hand, through we are collecting and counting bacteria, we need all these variables to remain constant again.

Actually, the cleaning substances we use in our experiment are the factors which affect our results most. One of these substances should contain NH3 and the other one should be chlorinated water. As a result, I choose pure NH3 and yellow soap for my experiment. Yellow soap is a commonly used cleaning substance which can be considered as chlorinated water.

Throughout the cleaning process, the cleaning substances should be used in a form of liquid solution in same ratios because of the physical condition of yellow soap. Therefore, we are going to use cleaning substances which are produced from pure NH3 and yellow soap. Before carrying out the trials, another essential variable had to be controlled: the concentration of NH3 and yellow soap. In order to achieve significant results and a better comparison, it is necessary to cover a wide range of concentrations. For this reason, in the following trials we will use different concentrations of NH3 and yellow soap (including chloride). Performing five trials for every concentration of each cleaning substance also allows us to make a more various comparison.

Types of bacteria investigated are also an important event. As we said before, Staphylococcus, Pseudomonas and Proteus mirabilis are the bacteria which have more probability than others to arise in our daily materials. However, as Dr. Christine Zurawski stated "In common areas, that's where you can have problems, If people are coughing and sneezing, they can leave viruses and bacteria on the things you touch."[6] we are totally aware of the fact that the bacteria collected in our experiment can be pathogenic. Therefore, I will try to perform the experiment with less harmful bacterium to provide the experiment to be safer. So, I'm going to choose non-pathogenic and least dangerous bacteria.

[6] *http://healthwatchmd.com/2011/11/germs-the-good-the-bad-the-ugly/*

DIAGRAM

Diagram 1: Diagram illustrating the steps of our experiments in a schematic way.

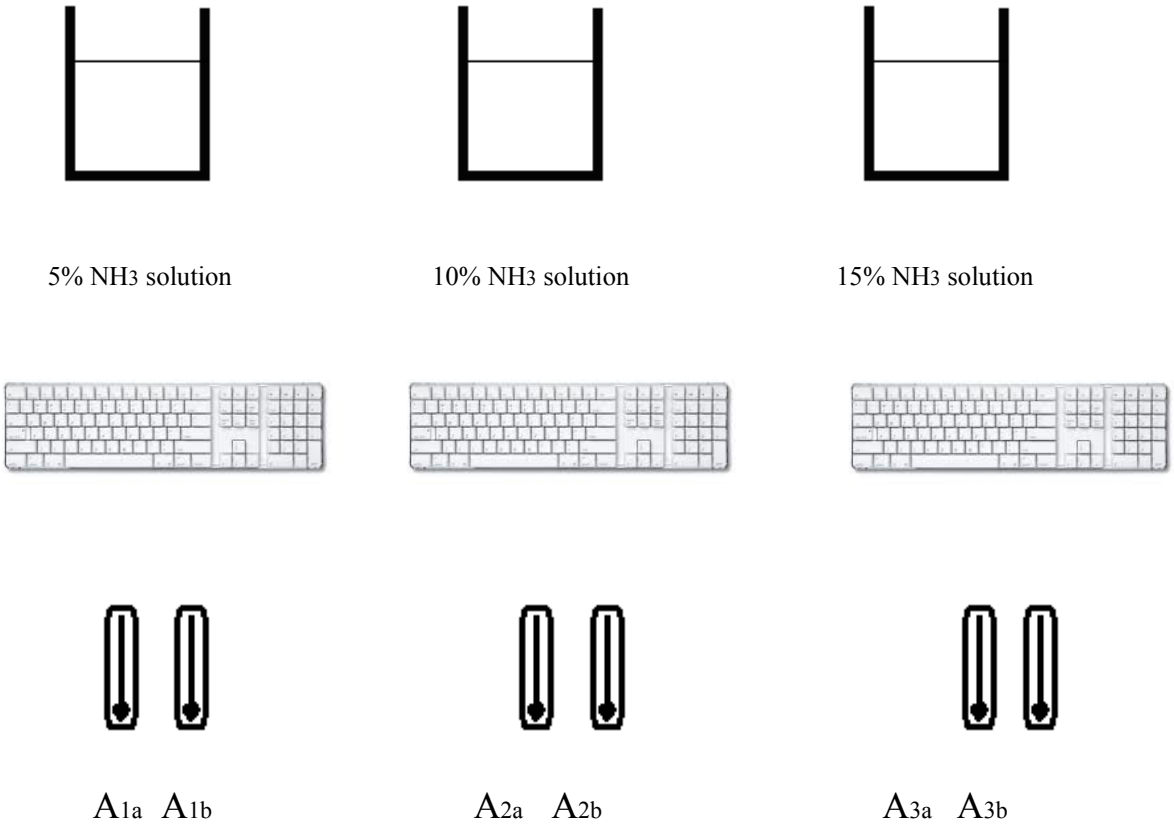
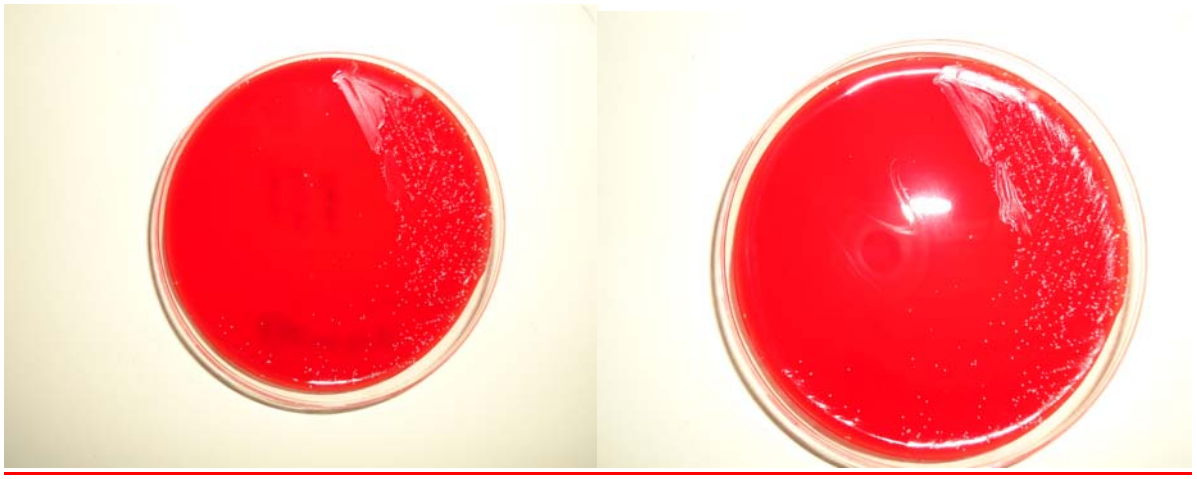


Diagram 2: Photo displaying the colonies formed in Petri dishes.



METHOD

Materials and Apparatus

30ml NH_3 solution	30 identical towels
30ml yellow soap	Pure water
6 Glass Beakers (200 ml)	2 pair of gloves
2 syringes (10ml)	Agar Swab
30 keyboards	30 Petri dishes

- Collect one sample from five of the keyboards by using sterile cotton-tip swabs. Name the taken samples as A_{1a}, A_{2a}, A_{3a}, A_{4a}, and A_{5a}. To take a proper sample and provide realistic data we should contact the stick of agar swab with all spots of the keyboard.
- Add 5 ml of NH_3 into 95 ml of water. In this way we gain 5% concentrated NH_3 solution in one of our glass beakers. We used one beaker for each solution to prevent them from mixing and changing the concentration involuntarily.
- Wear hand gloves and mask to minimize external contamination to the samples and agar plates and to be protected from the side effects of NH_3 like sharp smell.
- Sink one of the towels into the solution until it gets completely wet then squeeze the towel. Squeezing all the towels in an equal level allows us to stabilize the volume of cleaning substance used in each trial.
- Clean 5 previous keyboards by using the towel. Every part of the keyboards must be cleaned rigorously.
- After 1 minute of drying period, collect samples from the cleaned keyboards by using the cotton-tip of agar swab. Throughout this process, cotton-tip should contact with the keyboard in lots of spots in order to collect the samples homogenously.

- Put swabs into agar containing tubes. Mouths of the tubes are covered with parafilm to minimize the effect of external contamination. Name the samples as A_{1b}, A_{2b}, A_{3b}, A_{4b}, and A_{5b}. For example, A1a represents the first sample taken from a keyboard and A1b represents the sample taken from the same keyboard after it is cleaned. The period of time between these taken samples is approximately 1 minute. This situation is effectual for all other trials like A1a A1b, B1a B1b, and C1a C1b. After collecting and numerating samples are completed, all tubes are transferred to the laboratory for counting process.

- Fill one of the Petri dishes with blood agar. Divide it into two parts. Place the collected bacterium in A1a and A1b to the each divided parts of the Petri dish. Blood agar in Petri dishes keeps the bacterium alive for a long time until the counting process is finished. After incubating the Petri dishes in an oven at 37°C for 24 hours, colonies of bacterium are formed.

- After overnight incubation, colonies on each agar plate are counted under supervision of a microbiologist. The colonies on blood agars are reported as the number of colony formed. It was noted that no growth on agars was observed, so no further examination involving those agars was made because they don't affect the number of colonies.

- Use VITEK2 to identify the types of bacterium collected. VITEK2 and incubation can only be used in a laboratory.

For NH3 solution	For yellow soap solution
5% A_{1a} A_{1b}, … A_{5a} A_{5b}	5% D_{1a} D_{1b}, … D_{5a} D_{5b}
10% B_{1a} B_{1b}, … B_{5a} B_{5b}	10% E_{1a} E_{1b}, … E_{5a} E_{5b}
15% C_{1a} C_{1b}, … C_{5a} C_{5b}	15% E_{1a} $E_{1b.}$, … F_{5a} F_{5b}

- Repeat the same procedure for 10% and 15% concentration of NH3. Then perform the same process for 5%, 10% and 15% concentrations of yellow soap. For instance, B2b represents the second sample taken from the keyboard which is cleaned by 10% concentrated NH3 solution.

RESULTS

Experiment 1

Table 1: Set of results before the cleaning process is carried out, the samples were taken in a room temperature of 25°C and incubated for 24 hours at a temperature of 37°C.

Name of sample	Number of colonies of bacteria detected
A1a	3
A2a	2
A3a	5
A4a	4
A5a	8
B1a	5
B2a	4
B3a	6
B4a	7
B5a	2
C1a	2
C2a	0
C3a	5
C4a	7
C5a	9
D1a	5
D2a	1
D3a	4
D4a	0
D5a	8
E1a	0
E2a	2
E3a	3
E4a	5
E5a	1
F1a	8
F2a	4
F3a	1
F4a	3
F5a	5

Experiment 2

Table 2: Set of results acquired from the keyboards after being cleaned by different concentrations of NH3 solution, the samples are taken at a room temperature of 25°C and incubated for 24 hours at a temperature of 37°C.

Concentration of NH3	Name of Sample	Number of Colonies
5%	A_{1b}	2
	A_{2b}	0
	A_{3b}	3
	A_{4b}	3
	A_{5b}	4
10%	B_{1b}	1
	B_{2b}	0
	B_{3b}	3
	B_{4b}	2
	B_{5b}	1
15%	C_{1b}	0
	C_{2b}	0
	C_{3b}	0
	C_{4b}	1
	C_{5b}	3

Table 3: Set of results acquired from the keyboards after being cleaned by different concentrations of chlorinated water solution, the samples are taken at a room temperature of 25°C and incubated for 24 hours at a temperature of 37°C.

Concentration of Yellow Soap	Name of Sample	Number of colonies
5%	D_{1b}	2
	D_{2b}	0
	D_{3b}	3
	D_{4b}	3
	D_{5b}	4
10%	E_{1b}	0
	E_{2b}	0
	E_{3b}	3
	E_{4b}	2
	E_{5b}	1
15%	F_{1b}	0
	F_{2b}	0
	F_{3b}	0
	F_{4b}	1
	F_{5b}	3

Table 4: Main set of results acquired from the samples which illustrate the types of microorganisms detected and how much of them destroyed by different concentrations of NH_3 and chlorinated water solutions.

Type of Cleaning Substance	Concentration of cleaning substance (%)	Trials	Temperature(°C+0,05)	Type of Microorganisms Detected	Number of Colonie(s) Destroyed
NH_3	5%	A_{1a}	23,40	Pseudomonas	1
		A_{2a}	23,40	Proteus mirabilis	2
		A_{3a}	23,40	Staphylococcus	2
		A_{4a}	23,40	Staphylococcus	1
		A_{5a}	23,40	Proteus mirabilis	4
	10%	B_{1a}	24.20	Fungi	4
		B_{2a}	24.20	Staphylococcus	1
		B_{3a}	24.20	Fungi	3
		B_{4a}	24.20	Proteus mirabilis	5
		B_{5a}	24.20	Pseudomonas	3
	15%	C_{1a}	23.40	Fungi	2
		C_{2a}	23.40	-	0
		C_{3a}	23.40	Proteus mirabilis	5
		C_{4a}	23.40	Staphylococcus	6
		C_{5a}	23.40	Pseudomonas	6
Chlorinated Water (Yellow Soap)	5%	D_{1a}	23.50	Staphylococcus	3
		D_{2a}	23.50	Pseudomonas	1
		D_{3a}	23.50	Proteus mirabilis	1
		D_{4a}	23.50	-	0
		D_{5a}	23.50	Fungi	4
	10%	E_{1a}	24.00	-	0
		E_{2a}	24.00	Pseudomonas	2
		E_{3a}	24.00	Staphylococcus	3
		E_{4a}	24.00	Staphylococcus	3
		E_{5a}	24.00	Fungi	1
	15%	F_{1a}	23.00	Proteus mirabilis	8
		F_{2a}	23.00	Staphylococcus	4
		F_{3a}	23.00	Pseudomonas	1
		F_{4a}	23.00	Fungi	4
		F_{5a}	23.00	Pseudomonas	3

DATA ANALYSIS

Analysis of data displayed in Table 1-2-3-4 is shown in Statistical Analysis 1-2-3-4-5 below.

Statistical Analysis 1: Shows the results of "ANOVA: Single Factor" done which compares the effectiveness's of 5%, 10% and 15% concentrated NH_3 solutions.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
0,05	5	10	2	1,5
0,1	5	16	3,2	2,2
0,15	5	19	3,8	7,2

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	8,4	2	4,2	1,155963	0,347455	3,885294
Within Groups	43,6	12	3,633333			
Total	52	14				

Statistical Analysis 2: Shows the results of "ANOVA: Single Factor" done which compares the effectiveness's of 5%, 10% and 15% concentrated chlorinated water solutions.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
0,05	5	9	1,8	2,7
0,1	5	9	1,8	1,7
0,15	5	20	4	6,5

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	16,13333	2	8,066667	2,220183	0,151223	3,885294
Within Groups	43,6	12	3,633333			
Total	59,73333	14				

Statistical Analysis 3: Shows the results of "t-Test: Two-Sample Assuming Equal Variances" which is done to compare the two sets of data gained from 5% NH_3 and 5% chlorinated water.

t-Test: Two-Sample Assuming Equal Variances

	NH3	*Yellow Soap*
Mean	2	1,8
Variance	1,5	2,7
Observations	5	5
Pooled Variance	2,1	
Hypothesized Mean Difference	0	
Df	8	
t Stat	0,21821789	
P(T<=t) one-tail	0,416361458	
t Critical one-tail	1,859548033	
P(T<=t) two-tail	0,832722915	
t Critical two-tail	2,306004133	

Statistical Analysis 4: Shows the results of "t-Test: Two-Sample Assuming Equal Variances" which is done to compare the two sets of data gained from 10% NH_3 and 10% chlorinated water.

t-Test: Two-Sample Assuming Equal Variances

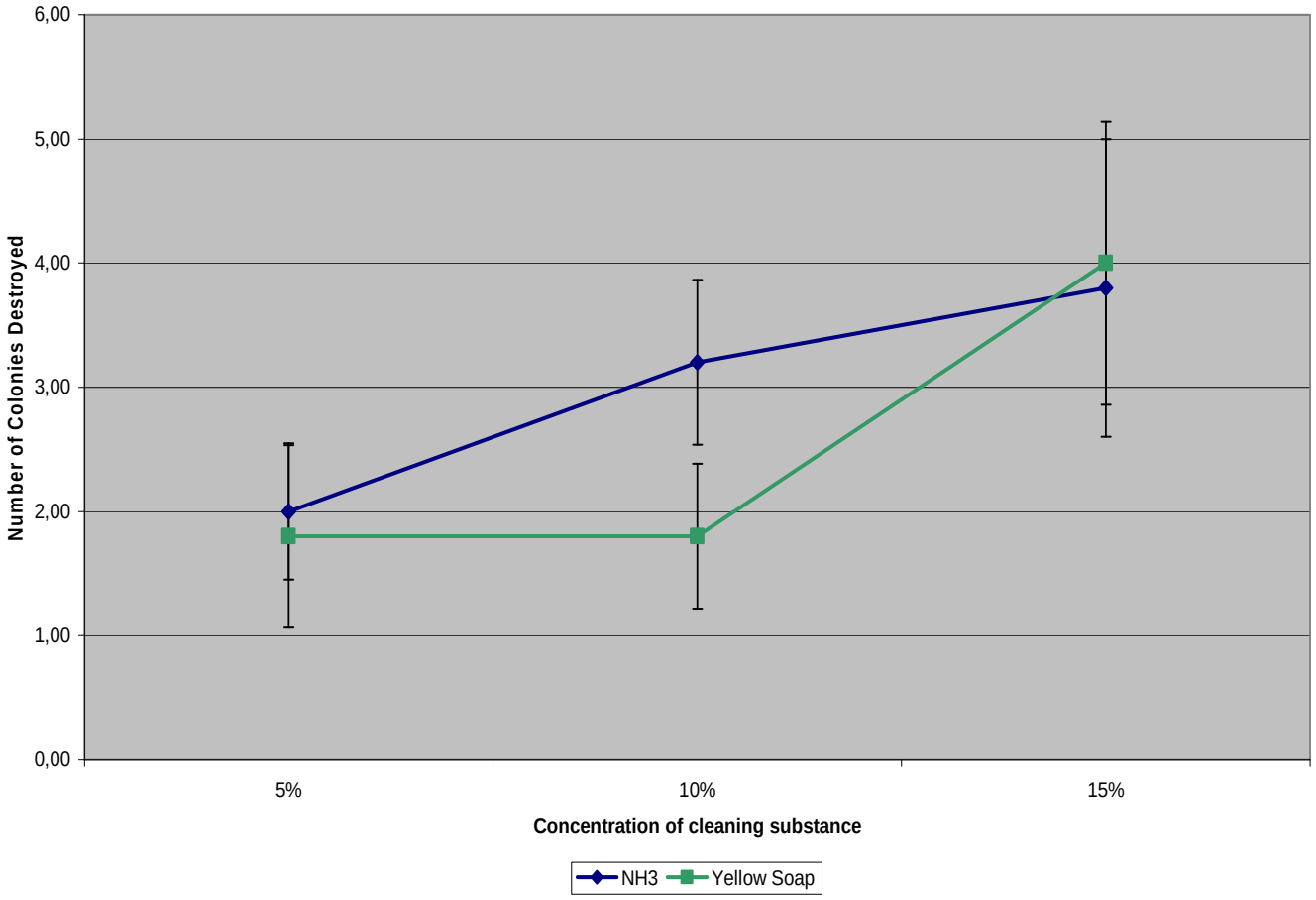
	NH3	*Yellow Soap*
Mean	3,2	1,8
Variance	2,2	1,7
Observations	5	5
Pooled Variance	1,95	
Hypothesized Mean Difference	0	
df	8	
t Stat	1,585187848	
P(T<=t) one-tail	0,075791855	
t Critical one-tail	1,859548033	
P(T<=t) two-tail	0,15158371	
t Critical two-tail	2,306004133	

Statistical Analysis 5: Shows the results of "t-Test: Two-Sample Assuming Equal Variances" which is done to compare the two sets of results gained from 15% NH_3 and 15% chlorinated water.

t-Test: Two-Sample Assuming Unequal Variances

	NH3	*Yellow Soap*
Mean	3,8	4
Variance	7,2	6,5
Observations	5	5
Hypothesized Mean Difference	0	
df	8	
t Stat	-0,120824419	
P(T<=t) one-tail	0,453404822	
t Critical one-tail	1,859548033	
P(T<=t) two-tail	0,906809644	
t Critical two-tail	2,306004133	

Graph 1: Graph of the experimental data, showing the average number of colonies of bacteria destroyed by each concentration of NH_3 and chlorinated water solutions.



EVALUATION

In order to analyze if NH_3 or chlorinated water is more effective, we compared the number of bacteria destroyed by varying concentrations of these two different cleaning substances. In the experiment, we used yellow soap which is considered as chlorinated water. I took samples from different keyboards which are interacted with same environment. After cleaning the keyboards with NH_3 and chlorinated water, samples were taken again and located in to Petri dishes filled with blood agar. To count the number of bacterium, the samples in Petri dishes are incubated for 24 hours. The incubation process allowed them to reproduce and create significant colonies which can be easily counted by naked eyes. Therefore, I learned the number of bacteria in keyboard before and after cleaning process. In other words, we can find the number of bacteria eliminated by a simple calculation. Moreover, in the experiment we used yellow soap which is considered as chlorinated water.

I used NH_3 and chlorinated water in a form concentrated solution which renders the cleaning process a lot easier and makes their conditions more equivalent. To make the comparison more detailed and realistic I used cleaning substance in three different concentrations (5%, 10%, and 15%). On the other hand, we compared the effectiveness of 5% concentrated NH_3 with 5% concentrated chlorinated water. Furthermore, I also analyzed that how different concentrations change the effectiveness of cleaning substances though it does not have role in rejecting any hypothesis.

In order to understand whether the results are statistically significant, a number of statistical analyses were done. First of all, I calculated the number of colonies of bacteria destroyed in each trial and transferred the collected data into tables. I used “ANOVA: Single Factor” for the data we gain from each cleaning substances. “ANOVA: Single Factor” proved us that changing concentrations of NH_3 and chlorinated water solutions didn’t influence the effectiveness of NH_3 and chlorinated water. “t-Test: Two-Sample Assuming Equal Variances” is the main statistical analysis which allowed me to compare the validity of NH3 and chlorinated water or which hypothesis should be rejected. We repeated “t-Test: Two-Sample Assuming Equal Variances” for three times and compared the effectiveness’s of each

concentrations of NH_3 and chlorinated water. In these both processes the result depends on the magnitude of P value.

The results support the hypothesis that NH_3 and chlorinated water are equally effective. In fact, they rejected the suggestion as NH_3 solution is used instead of chlorinated water, and as a result of this, the number of colonies of destroyed bacteria will increase. First of all, three "t-Test: Two-Sample Assuming Equal Variances" (see statistical analysis 1, 2) were performed for each concentrations indicated that there is no significant difference between the capabities of NH_3 and chlorinated water. However, there is some variation between the effectiveness of 10% NH_3 solution and 10% chlorinated water which is shown in graph. (see Graph 1). It could be assumed that p-values were found to be approximately 0.416 for 5%, 0.075 for 10% and 0.453 for 15% concentrated NH_3 and chlorinated water. All of the p values are higher than 0.05. Therefore, the alternative hypothesis was thrown out, and the idea suggests there is not a significant mean difference between the numbers of colonies of bacteria destroyed by two different cleaning products can be supported. Assuming this results to be true, the mean number of colonies of destroyed bacteria was calculated from the results and a graph was drawn to show its distribution. Furthermore, in "ANOVA: Single Factor" (see statistical analysis 3, 4, 5) which was performed to see how the concentration differentiates the number of colonies of destroyed bacteria, P-value is 0.347 for NH_3 and 0.151 for chlorinated water. For this reason, "ANOVA: Single Factor" showed that changing the concentration does not alter the efficiencies of NH_3 or chlorinated water.

In light of these analyses, our hypothesis was partially rejected. However, in some of the results there was a significant mean difference between the cleaning agents in terms of their bactericidal effects. As we said that graph1 displays the data we gain in a different view. When I compared the impacts of NH_3 and chlorinated water from graph 1, I clearly saw that 5% and 15% concentrations of two different cleaning substances were equally effective. Furthermore, an unexpected fact occurred. According to graph 15% concentrated NH_3 is less effective than 15% chlorinated water solution. This unexpected result was certainly caused by some specific errors. Long error bars of 15% concentrated NH_3 and chlorinated water also showed that the amount of error done in that stage is pretty high. Although the statistical

results show that 10% concentrated NH_3 and chlorinated water solution are equally effective, it is shown in the graph1 that the average number of colonies of destroyed bacteria by 10% concentrated NH_3 solution is higher than 10% chlorinated water solutions. For this reason, the results of comparison of 10% concentrated NH_3 and chlorinated water is the closest one to the expected results in spite of the fact that it's not statistically proven.

To gain more expected, realistic and relevant data and improve the experiment done, far more trials should be performed and some specific errors should be prevented. For instance; after examining Graph 1 error bars, it can be seen that the highest errors were made while testing 15% concentrated NH_3 and 15% concentrated chlorinated water. In order to provide a good estimate of the mean and ensure no error is made, it is necessary to repeat the experiment as often as possible. However, all of the errors can not be eliminated by simply repeating the trials more. Other errors which have been made would have to be dealt with the slight change of the procedure or giving some effort. For example, while taking the samples, the cotton of agar swab should contact with the keyboard as much as possible. However, the cotton of the agar swab probably contacted with the areas which contain a high or low number of bacteria. This also explains the fact that why the number of bacteria collected from the keyboards is varied and there is no bacteria collected in samples. To exclude this error, more samples should be taken.

Additionally, some weaknesses of our methods can lead us to errors. Another source of error may have been occurred during the cleaning process. I used identical towels in each trial, however stabilizing the volume of NH_3 or chlorinated water solutions in towels was not possible and led us to make an error. Although I tried to sink the towels into solution completely and squeezed them equally, the towels didn't absorb the solutions homogenously. Therefore, keyboards were not cleaned by the same amount of solutions. Also, incubating process can lead us to unexpected results. For instance, some of bacteria in blood agar can not reproduce properly and create colonies because the temperature throughout incubation is not constant. Nonetheless, the number of bacteria in blood agar is 7, the number of colonies occurred can be counted as 5. Instead of counting colonies, number of colonies formed per ml can also be measured and some errors can be prevented.

Type of bacteria collected and investigated also influenced our data and results. I dealt with non-pathogenic bacteria which carry a low risk of infections and the samples were collected only from keyboards in order to limit the probability of any facing pathogenic bacteria. Therefore, none of infectious or pathogenic bacteria species grew from our samples. If pathogenic species had grown, we may have obtained more valid results hence they are the main cause of infections. In order to increase the probability to collect pathogenic bacteria, samples might be collected from different materials such as door handle, cell phone or money which are used commonly. In addition to this, using one type of a cleaning substance, microorganism and a less number of keyboards can make our experiment more controlled.

CONCLUSION

As I stated before, p values of each t-test should be lower than 0.05 to accept the suggestion which implies that NH_3 is more effective than chlorinated water. However, the results of the study showed that there isn't any significant difference between the efficiencies of these two cleaning agents. So, it can be concluded that NH3 and chlorinated water are equally effective on bacteria we interact with in our daily lives. If I have to find out which one of these cleaning products should be used, we can say that NH_3 should be more convenient to be used as long as their bactericidal efficiency is equal. Moreover, NH_3 can be used as an alternative disinfectant to avoid the risks that chlorinated water can cause. The second aim of our experiment was to determine the effect of varying concentrations on the efficiency of NH_3 and chlorinated. According to the results of ANOVA, we saw that changing the concentration doesn't affect the validity of NH_3 or chlorinated water.

This study leads us to new research questions such as; "Is there any other cleaning substance which can be used instead of chlorinated water?" To conclude, the reason why I choose this topic for my extended essay is to figure out which one of these cleaning agents is more available for people to get protected from harmful bacteria coming from environment. Even though I didn't achieve the expected results, my aim is partially fulfilled and my research question is completely answered.

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