How Does the Presence of Chlorine Affect the Locomotion of An Earthworm?

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January 27, 2020

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Abstract:

The chlorine in the water can transform into toxic elements and chemicals such as dichloramines, trichloramines, and monochloramines[1]. However, the trichloramines are the gist of the problem[2]. The trichloramines are a poison like chemical that sit low towards the water and infest the lungs of swimmers with harmful, asthma-like symptoms[3]. The chlorine itself is not quite as dangerous, but it causes burning and itchy skin[4]. However, there are some rare cases of diseases caused by chlorine. Scientists wanted to figure out how the presence of chlorine affects earthworm locomotion. The materials needed for the experiment are simple and so is the set-up. All it takes is earthworms, cups, and dirt. The set-up included placing a cup in a safe indoor pool area and hydrating the worms regularly with clean water. The worms were not to be placed in dirt when exposed to the air quality. When the earthworms have been exposed for approximately 3 hours, the scientists would take the earthworms out of the pool area and test their burrowing time. For comparison, the scientists would need to test different earthworms burrowing time when they are not exposed to the air quality. The scientists also tested chlorine by taking chlorinated water from two different pools and exposing the earthworms to the water. The scientists would describe the seriousness of the sensorimotor reaction by creating a descriptive scale beforehand and rate every reaction on the scale when doing the experiment. The results showed that indoor pool air quality is a huge problem and that something needs to be done about how we can stop the

[1] "Pool Indoor Air Quality: Why it Matters to Your ... - SwimSwam." 22 Jan. 2014, https://swimswam.com/pool-indoor-air-quality-matters-health-performance-part-1/. Accessed 17 Feb. 2020.
[2] "Pool Indoor Air Quality: Why it Matters to Your ... - SwimSwam." 22 Jan. 2014, https://swimswam.com/pool-indoor-air-quality-matters-health-performance-part-1/. Accessed 17 Feb. 2020.
[3] "Pool Indoor Air Quality: Why it Matters to Your ... - SwimSwam." 22 Jan. 2014, https://swimswam.com/pool-indoor-air-quality-matters-health-performance-part-1/. Accessed 17 Feb. 2020.
[4] "ATSDR - Agency for Toxic Substances - CDC." 21 Jan. 2015, https://www.atsdr.cdc.gov/PHS/PHS.asp?id=683&tid=36. Accessed 17 Feb. 2020.

destruction of our bodies[5]. The earthworms burrowing time was greatly affected by the air quality and was proven to be statistically significant. So did the chlorinated water which was statistically significant with water from two different pools. The earthworms were affected by the air quality because the air quality destroyed some of the locomotion neurons inside the earthworms[6]. This is why it took them longer to burrow. The earthworms were probably affected by certain pool water because the chlorine concentration was somewhat high but not to a major extent. However, when they were more affected, there must have been a higher concentration of chlorine in the water to irritate the earthworms causing a much more extreme sensorimotor reaction[7]. The scientists could have done better by testing the long-term effects of air quality. Also, the scientists also could have gathered more information on the different treatments of pool water to discover why the earthworms had different reactions to different types of chlorinated pool water. The earthworms data was representable in both experiments to support my hypothesis. Finally, one of the ways to treat the air quality is to invent a vacuum that sucks the bad air out of the pool area and replace it with fresh air.

Introduction:

In Air Quality constructed by chlorine, there are trichloramines (otherwise known as nitrogen trichloride), dichloramines, and monochloramines[8]. Chlorine is used to disinfect pool water and

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[5] "Indoor Pool Air Quality: Addressing One of the Nation's Most ...." 16 Dec. 2016, https://www.swimmingworldmagazine.com/news/indoor-pool-air-quality-addressing-one-of-the-nations-most-underrated-issues/. Accessed 17 Feb. 2020.

[6] "Worms Can Feel Pain, Research Indicates - The New York ...." 11 Sep. 1979, https://www.nytimes.com/1979/09/11/archives/worms-can-feel-pain-research-indicates.html. Accessed 17 Feb. 2020.

[7] "Indoor Pool Air Quality: Addressing One of the Nation's Most ...." 16 Dec. 2016, https://www.swimmingworldmagazine.com/news/indoor-pool-air-quality-addressing-one-of-the-nations-most-underrated-issues/. Accessed 17 Feb. 2020.

[8] "The Facts About Chlorine - Health.NY.gov - New York State." https://www.health.ny.gov/environmental/emergency/chemical_terrorism/chlorine_general.htm. Accessed 17 Feb. 2020.

it is extremely reactive meaning it will transform to another chemical almost immediately into the disinfection phase of pool water[9]. Monochloramines and dichloramines are usually what chlorine transfers to right away[10]. They also usually don't harm people or other organisms. However, trichloramine's do. Trichloramines are what monochloramines and dichloramines transform into when disinfecting the pool water[11]. According to the SwimSwam article "Indoor Pool Air Quality", "Trichloramines are the crux of the problem." Of course, they are talking about how pool air quality is dangerous. There's even a cough named after the air quality-related problems. It's called swimmers cough. Thousands of swimmers around the world have experienced constant shortness of breath, coughing, and wheezing[12]. Now, not a lot of chlorine is used for water treatment. Only 1-16 milligrams of chlorine are used in one liter of pool water[13]. This means that the chlorine is not as concentrated as you think. However, when the monochloramines and the dichloramines combine with sweat, urine, or other substances of that category, the chlorine will turn into trichloramines and become toxic[14]. The toxins of air quality could act as a poison to swimmers[15]. Trichloramines are much heavier than oxygen so they stay

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[9] "The Facts About Chlorine - Health.NY.gov - New York State." https://www.health.ny.gov/environmental/emergency/chemical_terrorism/chlorine_general.htm. Accessed 17 Feb. 2020.
[10] "Pool Indoor Air Quality: Why it Matters to Your ... - SwimSwam." 22 Jan. 2014, https://swimswam.com/pool-indoor-air-quality-matters-health-performance-part-1/. Accessed 17 Feb. 2020.
[11] "ATSDR - Agency for Toxic Substances - CDC." 21 Jan. 2015, https://www.atsdr.cdc.gov/PHS/PHS.asp?id=683&tid=36. Accessed 17 Feb. 2020.
[12] "Indoor Pool Air Quality: Addressing One of the Nation's Most ...." 16 Dec. 2016, https://www.swimmingworldmagazine.com/news/indoor-pool-air-quality-addressing-one-of-the-nations-most-underrated-issues/. Accessed 17 Feb. 2020.
[13] "ATSDR - Agency for Toxic Substances - CDC." 21 Jan. 2015, https://www.atsdr.cdc.gov/PHS/PHS.asp?id=683&tid=36. Accessed 17 Feb. 2020.
[14] "Indoor Pool Air Quality: Addressing One of the Nation's Most ...." 16 Dec. 2016, https://www.swimmingworldmagazine.com/news/indoor-pool-air-quality-addressing-one-of-the-nations-most-underrated-issues/. Accessed 17 Feb. 2020.
[15] "Indoor Pool Air Quality: Addressing One of the Nation's Most ...." 16 Dec. 2016, https://www.swimmingworldmagazine.com/news/indoor-pool-air-quality-addressing-one-of-the-nations-most-underrated-issues/. Accessed 17 Feb. 2020.

low to the water[16]. Unfortunately, the trichloramines populate the area where swimmers breathe. This is what gives the swimmers asthma-related symptoms[17]. According to the article “Indoor Pool Air Quality: Addressing One of the Nation’s Most Underrated Issues”, “At the 2013 USA Swimming Winter Junior National Championships in Greensboro, North Carolina, 2016 Olympian Caeleb Dressel, was hospitalized in the middle of the meet.” The causes were ruled out to be from the air quality. The symptoms Caeleb had were violent coughing, burning eyes, and dry and blotchy skin. There has to be something done about this air quality. Looking even beyond the air quality, the chlorinated water has some effect on humans too. When chlorine enters the body, as a result of breathing, swallowing, or skin contact, it reacts with water to produce acids[18]. The acids are corrosive and damage cells in the body when coming into contact. The cells can vary from being critical in movement or the structure of skin. If you swallow chlorinated water, you may end up getting a sickness called Recreational Water Illness (RWI)[19]. The symptoms for RWI are diarrhea, dermatitis, and otitis externa which is better known as swimmer's ear[20]. Sometimes you might end up swallowing bacteria called pseudomonas aeruginosa which can cause various diseases and sicknesses[21]. However, when it comes to

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[16] "Pool Indoor Air Quality: Why it Matters to Your ... - SwimSwam." 22 Jan. 2014, https://swimswam.com/pool-indoor-air-quality-matters-health-performance-part-1/. Accessed 17 Feb. 2020.

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[18] "Indoor Pool Air Quality: Addressing One of the Nation's Most ...." 16 Dec. 2016, https://www.swimmingworldmagazine.com/news/indoor-pool-air-quality-addressing-one-of-the-nations-most-underrated-issues/. Accessed 17 Feb. 2020.

[19] "What to Do if You Get Water in Your Mouth from Pools or the ...." 1 Jul. 2015, https://iccsmiles.com/what-to-do-if-you-get-water-in-your-mouth-from-pools-or-the-ocean/. Accessed 17 Feb. 2020.

[20] "Common Recreational Water Illness - Verywell Health." 5 Dec. 2019, https://www.verywellhealth.com/can-i-get-sick-from-swimming-1192003. Accessed 17 Feb. 2020.

[21] "Common Recreational Water Illness - Verywell Health." 5 Dec. 2019, https://www.verywellhealth.com/can-i-get-sick-from-swimming-1192003. Accessed 17 Feb. 2020.

earthworms, we are testing for more of the minor symptoms of chlorine exposure. For instance skin. Dry skin is one of the most common problems after exposure to chlorine. When your skin is dry, it itches and burns[22]. Earthworms breathe through their skin so when being exposed to a chemical like chlorine, the earthworms might have trouble breathing[23]. So overall, chlorine is a problem too. The scientists in this experiment used earthworms because they have a similar nervous system to humans in terms of locomotion[24]. There are similar dopamine transmission and adrenaline transmission[25]. This means that the scientists will be looking for slow movement or spasmodic movement.

Because of the harmful air quality in indoor pools, three scientists felt that it was important to complete an investigation on how air quality affects earthworm's burrowing time. The scientists wanted to solve the question, how does the presence of chlorine affect the locomotion of earthworms? The scientists did this to prove how underrated the air quality problems are in the world, and that something needs to be done so thousands of people won't be harmed.

If the scientists, expose earthworms to indoor pool air quality, then the burrowing time will increase because the air quality would affect their locomotive neurons and breathing. The worms will have trouble breathing when the toxins touch their skin causing them to have trouble

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[22] "The Facts About Chlorine - Health.NY.gov - New York State." https://www.health.ny.gov/environmental/emergency/chemical_terrorism/chlorine_general.htm. Accessed 17 Feb. 2020.

[23] "Common Earthworm - National Geographic." https://www.nationalgeographic.com/animals/invertebrates/c/common-earthworm/. Accessed 17 Feb. 2020.

[24] "Worms Can Feel Pain, Research Indicates - The New York ...." 11 Sep. 1979, https://www.nytimes.com/1979/09/11/archives/worms-can-feel-pain-research-indicates.html. Accessed 16 Feb. 2020.

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burrowing and confusion. The earthworms will also have some bad neuronal tweaks after full exposure to the air quality causing their movement to be more corrupt. Also, if the scientists expose the earthworms to indoor pool chlorinated water, the earthworm will have an abnormal reaction. The chlorine will come in contact with the earthworms skin causing them to be irritated and have respiratory problems. After being exposed to the air quality, the worms took an incredibly long time to burrow than when they are not exposed to harmful air quality. Then after being exposed to the chlorinated water, the earthworms sensorimotor reaction was sort of mixed but still proven to have affected the earthworms in a significant manner.

Materials and Methods:

Materials (Includes materials for both experiments):

1. A minimum of 6, 16 oz. red solo cups
2. A minimum of 15 adult red worms from NASCO (12 for air quality testing and 3 for chlorine testing)
3. Indoor Pool Area
4. 11 ¼ by 7 ⅜ in. metal tray
5. 8 oz. of chlorinated pool water per source (Use 2 different sources)
6. 1 Dropper
7. 4 scoops of Burpee eco-friendly potting soil (2 scoops per experiment)
8. Stopwatch
9. Safety goggles

Experiment Set-Up

First, for the air quality testing, the scientists placed six worms inside a cup.

Secondly, the scientists made sure the cup did not have much soil for the earthworms to burrow because they wanted the earthworms to be in contact with the air quality similar to what swimmers are.

Thirdly, they placed a cup in a safe area of the pool to make sure nobody else interferes with the

experiment.

Finally, the scientists had a cup with dirt on stand by to test the earthworm's burrowing time immediately after the experiment.

Now the scientists were ready to begin the air quality portion of the experiment.

For the chlorinated water, first off, the scientists took one worm and placed it on an 11 ¼ by 7 ⅜ in. metal tray.

Secondly, adjacent to where the earthworm was located, the scientists made a ring of one of the types of chlorinated water using a dropper.

Thirdly, the scientists had a spray bottle on standby in case the earthworms had an extreme reaction and needed to get rid of the contaminant on their bodies.

Now the scientists were ready to begin the chlorinated water experiment.

Methods

First off, the scientists placed the cup that contained six earthworms, in a safe place so the earthworms would not be disturbed, but relative to the pool water level.

Secondly, for precaution, the scientists made sure to watch the cup and spray the worms with a spray bottle full of clean water regularly. The spray bottle was necessary for the earthworms to stay hydrated. The scientists did not want dehydration as a variable in their experiment.

Thirdly, after the worms were exposed to the air quality for approximately three hours, the scientists were ready to begin the process of testing the earthworm's burrowing time.

Fourthly, when testing the burrowing time, the scientists took the worms out of the indoor pool air quality so the earthworms would be located in a more natural environment.

Fifthly, the scientists placed all the earthworms in a cup with approximately two scoops of dirt.

Sixthly, when the scientists placed the worms in the burrowing chamber (or solo cup with dirt),

they made sure to start a stopwatch.

Finally, once each earthworm burrowed the scientists will record the time the stopwatch says. The scientists used their cell phones to record the data and eventually switched it over to a spreadsheet on their computers. For the chlorinated water experiment, first, the scientists would need to come up with a list of 1-10 on how extreme the earthworms reactions would be when they come in contact with the contaminant. The scientists already knew that when the earthworms had no reaction, they would label it as a 0 on the rating scale. Here is an example of what the scientists did for this experiment:

1. Minimal Avoidance
2. Mild Avoidance
3. Strong Avoidance
4. Head Bobbing and Extreme Avoidance
5. Slight Spasm
6. Mild Spasm
7. Strong Spasm
8. Extreme Spasm and Confusion
9. Paralysis
10. Death

The rating given to each trial was under the scientist's discretion.

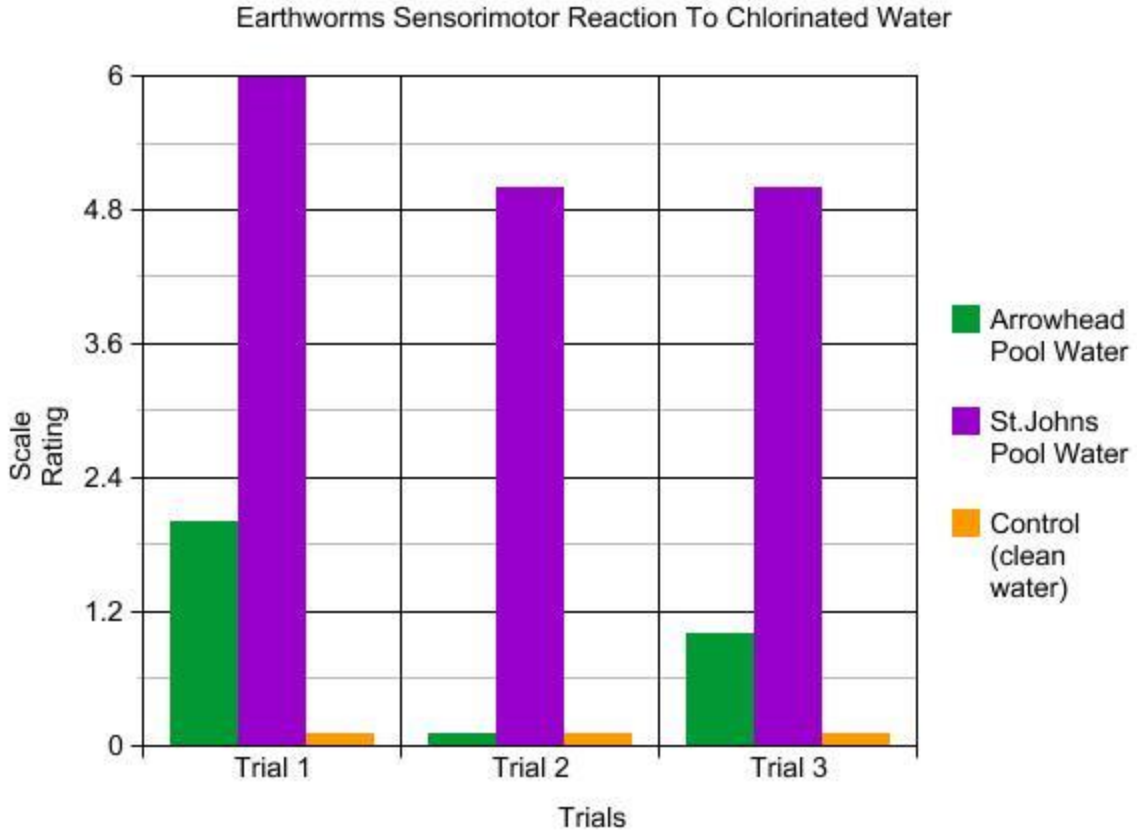
Secondly, the scientists placed the earthworms in the ring surrounded by chlorinated water. When the earthworms came in contact with the contaminant, the scientists would record the earthworm's sensorimotor reaction.

Make sure to do this test again with another type of pool water and clean water to use as the control. Every reaction the scientists had seen was discussed before typing the data into a spreadsheet. This way made the experiments quick and easy. If trying to replicate this experiment, please take mind of some of the safety precautions. Always wear goggles when attempting an experiment like this. If someone doing the experiment has a respiratory disease or illness (for example asthma), the air quality experiment is not recommended. Try to refrain from

coming into contact with the chlorine especially consuming it as it may cause illness or injury. The outcomes of the experiment were determined using a stopwatch and creating a scale used to define the seriousness of the sensorimotor reaction of the earthworms.

Results:

For air quality, the experiment was conducted by placing six earthworms in an indoor pool area for three hours and then placing them in a burrowing chamber to time their burrowing. Meanwhile, the chlorine water experiment was performed by collecting chlorinated water from two different pools. The scientists used a dropper to create a ring of chlorinated water, place the earthworm in the center of the ring, and record the seriousness of their sensorimotor reaction once the earthworm comes within contact of the chlorinated water. The reason for doing these two experiments was to prove how harmful air quality can be and possibly what chlorine might do to our nervous system as well. We wanted to prove that this is more serious of a problem than people say it is. If the scientists, expose earthworms to indoor pool air quality, then the burrowing time will increase because the air quality would affect their respiratory system. Also, if the scientists expose the earthworms to indoor pool chlorinated water, the earthworm will have an abnormal reaction.



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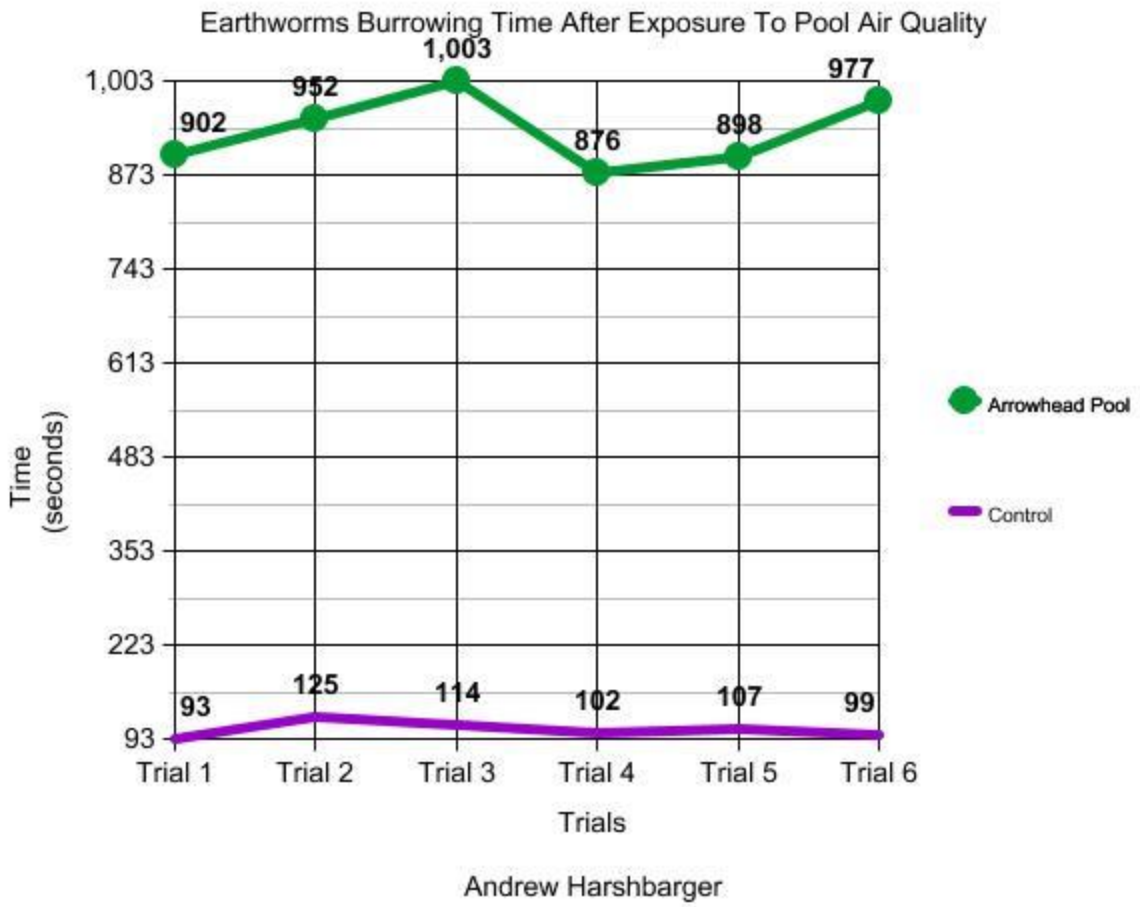

Arrowhead Air Quality Average (seconds)	Control Air Quality (seconds)	t-value	Statistically Significant Or Not Statistically Significant
934.67	106.67	39.3651	Statistically Significant

Arrowhead Chlorine Water Average (scale)	St. Johns Chlorine Water Average (scale)	Control Clean Water Average (scale)	t-value	Statistically Significant Or Not
1	5.33	0	1.7321 (Arrowhead) 16 (St. Johns)	Both Statistically Significant

After exposure to the air quality, the earthworms had an incredibly hard time burrowing. There were patterns of extreme slowness and confusion brought upon the earthworms who were exposed. One earthworm even took as long as 16 minutes and 43 seconds or 1,003 seconds as seen on the graph. The average burrowing time for the control earthworms was 1 minute and 46 seconds, while the average burrowing time for the exposed earthworms was 15 minutes and 35 seconds. Then, when testing the earthworms sensorimotor reaction with chlorinated water, the average control with regular water was 0. The Arrowhead High school pool didn't affect the earthworms that much either with an average sensorimotor reaction of 1. However, St. John's pool seemed to have much more of an effect because the earthworms' average sensorimotor reaction reached 5.33 on the scale. When looking at the statistical side of things, the air quality's t-value, a statistic that determines what is statistically significant using the control and data collected in an experiment, was well over the mark that is considered statistically significant at around 39.4. It showed that the dangers of air quality are really that bad of a problem.
Meanwhile, the chlorinated water aspect was somewhat similar. The t-value for Arrowhead's sensorimotor reaction data was at the 1.7 range which is still considered statistically significant. However, the St. Johns chlorine water had another high t-value at 16.
My hypothesis for both the air quality and chlorinated water was statistically proven by far. All t-values were above 1 (the value used to show what is statistically significant) while one t-value was almost at 40.

Discussion:

The trends in the data showed how dangerous air quality is because the earthworms took as much as 11 times more when exposed than when not exposed to the air quality. The results of the air

quality experiment showed that this is a definite problem in the world today. The air quality data was not a coincidence, it was beyond supportive and somewhat horrifying that people breathe that air on a daily basis. The chlorinated water experiment might not have had the same impact that the air quality did but it still was shown to be significant findings. However, there was only so much success in the investigation. I believe that the scientists could have gone into more depth about the contents of chlorine. Since two pools had an extremely different effect on the earthworms, the scientists could have gathered data on the different treatments of pool water to make sense of the difference in data. Another possibility that future scientists could do is, if they had enough time, to try to test the long-term effects of the pool air quality on earthworm's nervous system. In the data shown from the collected experiment, the air quality had affected the earthworms by far. However, to be able to understand and have representable data for the long-term effects of indoor pool air quality, scientists would be able to make more crucial conclusions. The pool air quality affected the earthworms because the trichloramines that are dispersed in the air, had almost poisoned the earthworms. This type of poisoning had corroded the neurons inside of the earthworm's nervous system[26]. As for the chlorinated pool water, there was a wide variability of the earthworm's sensorimotor response. This is probably because different pools might have different techniques and chemicals used to disinfect their pool water. As for how the chlorine affected the earthworms, the concentrated chlorine was absorbed by the earthworm's skin irritating and causing a lingering burn[27]. However, it only affected the earthworms a couple of times and it was only from specific pool water. When the earthworms

[26] "Worms Can Feel Pain, Research Indicates - The New York ...." 11 Sep. 1979, https://www.nytimes.com/1979/09/11/archives/worms-can-feel-pain-research-indicates.html. Accessed 17 Feb. 2020.
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weren't affected, the main reason is that the specific pool water made them feel uncomfortable, but no pain[28]. Another possibility of this is that the earthworms just treated the water like normal, clean, and freshwater. I thoroughly believe that this experiment has been able to advance the research of this topic by stressing about how serious this is. This experiment has allowed the demonstration of further innovations of this topic which will hopefully show that indoor pool air quality is a real-world problem and maybe even chlorine itself. In essence, indoor pool air quality needs to be thought about as a bigger problem than people make it out to be. The pool air is toxic and is damaging everyone who interacts with it[29]. An important way to prevent air quality is to stop the pool's intake of sweat, urine, lotions, and body oils before the chloramines can convert into trichloramines[30]. Showering and not urinating in the pool is an important factor in this. However, not many people oblige by these rules. Showering before entering the pool is considered a hassle and heavily hated among competitive and recreational swimmers. Furthermore, peeing in the pool is shockingly a big problem with all swimmers. Even the single greatest swimmer of all time, Michael Phelps does it[31]. Sometimes showering and not urinating in the pool just doesn't work. That's why we should come up with greater ideas on how to take away the heavy trichloramines and replace them with the air outside of the indoor pool area. However, inventions this great and inexpensive, are still needed in the world today. If we can build a vacuum that sucks the trichloramines out of the pool area and replace them with regular

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[28] "Worms Can Feel Pain, Research Indicates - The New York ...." 11 Sep. 1979, https://www.nytimes.com/1979/09/11/archives/worms-can-feel-pain-research-indicates.html. Accessed 17 Feb. 2020.

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[30] "Indoor Pool Air Quality: Addressing One of the Nation's Most ...." 16 Dec. 2016, https://www.swimmingworldmagazine.com/news/indoor-pool-air-quality-addressing-one-of-the-nations-most-underrated-issues/. Accessed 17 Feb. 2020.

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and safe air, then indoor pools would finally be safe[32]. Research can be further demonstrated on this topic by designing and testing different toxic air quality prevention tactics[33]. This will allow everyone who swims in an indoor pool to feel safe when entering the water.

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