Does the presence of Coliform and *E*. coli increase or decrease measured at set distances downstream from a Life deluxe chlorine/bromine chlorinator in the Jukskei River as it flows through the Dainfern Estate?

Research Question

Does the presence of Coliform and *E*. coli increase or decrease measured at set distances downstream from a Life deluxe chlorine/bromine chlorinator in the Jukskei River as it flows through the Dainfern Estate?

Environmental Issue

The need for adequate sanitation facilities and proper sanitation has never been greater. Today more than half the population on earth openly defecates (gatesfoundation.org). Human waste then enters streams and watersheds for many different reasons, including water runoff, rain, and gaps/breaks in sanitation systems. *E*. coli, cholera, and other waterborne diseases deeply impact small communities/cities that do not have access to clean sanitation and hygiene as shown in the June 2018 Global Citizen report. "Poor sanitation, which is widely accepted as a chief contributor to waterborne diseases, is the cause of more than 1,200 deaths of children under five-years-old per day, which is more than AIDS, measles, and tuberculosis combined." (gatesfoundation.org). Experts have traced open defecation back to the lack of infrastructure, which is why poor sanitation facilities are the "greatest nightmare of Africa" (Zaynetdinova). For example, 40% of schools in Ghana do not have access to toilets, which means the children are openly defecating. On top of this, 20% of Ghanaian children are stunted (Zaynetdinova).

When sewage gets into rivers, it is harmful to the communities surrounding it and damages the environment. Sewage waste is high in nitrates and phosphates, which means that it is a great fertilizer for plant growth (randwater.co.za). However, in this case this is not a good thing because it leads to increased algae growth/blooms (randwater.co.za). When algae blooms grow, they block sunlight from reaching the fish and plants towards the bottom of the river. In addition, algae depletes the oxygen in the river, which kills fish or drives them out of the area (Hoyle, Lerner and Richmond).

I will be directing my focus towards Johannesburg, South Africa. This investigation will test the Jukskei River in the Dainfern stretch for traces of *E.* coli. I will be starting at the river entrance in the Dainfern Estate and moving along the river to the exit point of the adjacent Dainfern Estate. The Dainfern Estate recently purchased Life deluxe chlorine/bromine chlorinators which kill traces of *E.* coli in the Jukskei River. As part of my investigation, I will determine whether or not these Life chlorinators are effective in killing *E.* coli and, if so, whether this result continues downstream to the point where the river exits the Estate. The chlorinators from Life are small floating chlorinators that hold six 1 inch diameter chlorine/bromine tablets that slowly dissolve in the water, which releases chlorine and bromine to kill algae and *E.* coli. The cost of these chlorinators is R225 each. The chlorinators will not clean the water to the point that it could be used for irrigation or drinking, but should make the water less toxic and reduce the odor.

Connections to Research Question

In this investigation, I will be performing coliform and *E*. coli tests on water samples that I will be collecting from the Jukskei River. The purpose of this investigation is to test the Life deluxe chlorine/bromine chlorinators which were recently installed into the Jukskei River by the Dainfern Estate. The expectation is that there will not be any traces of *E.* coli directly downstream from the chlorinators. I will also test the river further downstream to determine whether the presence of *E.* coli re-emerges. If the Life chlorinators prove to be successful against *E.* coli, then other Dainfern Estates around Johannesburg could consider utilizing similar products to clean up the rivers and ponds.

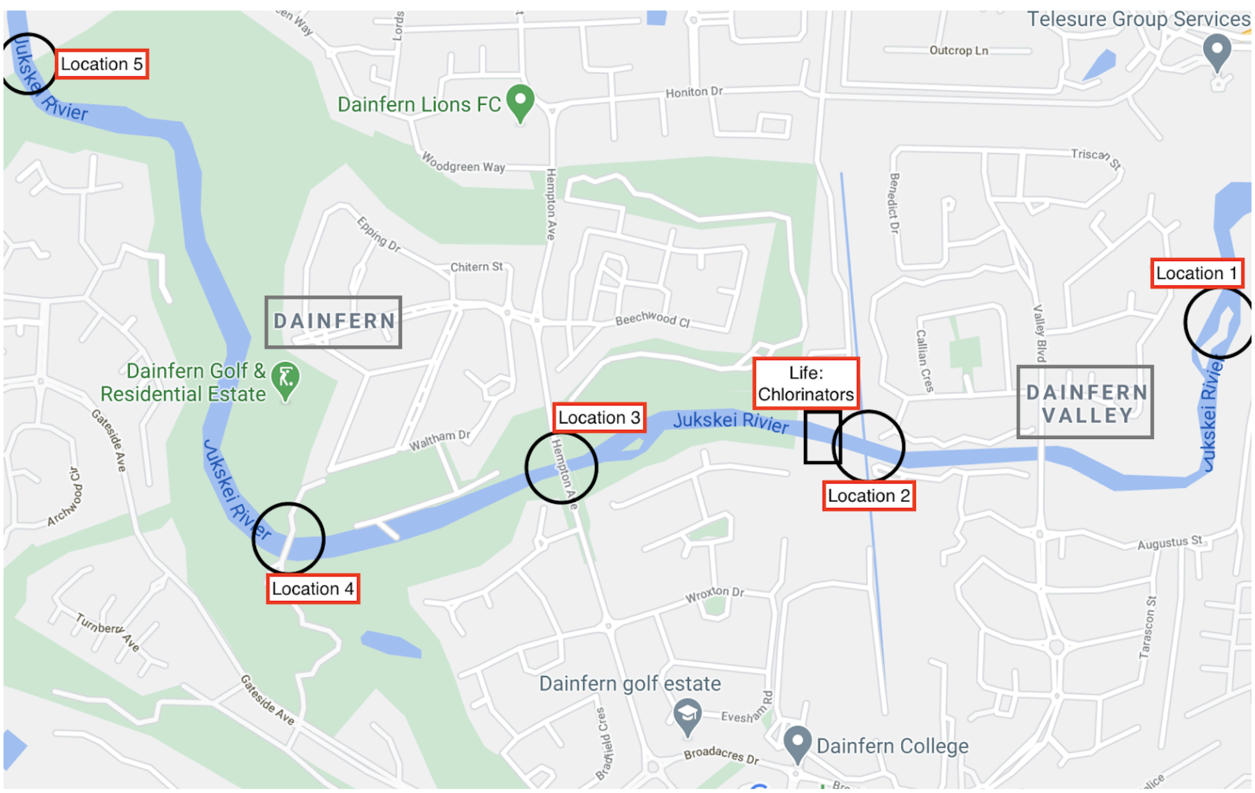
I chose this topic and research question because I live in one of the Dainfern Estates. When we moved in, everyone told us that the river has a high concentration of *E.* coli caused by sewage from a low-income community upriver from Dainfern. I am interested to know whether the chlorinators in the Dainfern Estate are an effective solution and to test the assumption that the *E.* coli in the river is coming from outside the Estate. If this is the case and the chlorinators are effective, then the river should continue to be free of *E.* coli at least until it leaves the the Dainfern Estate.

Hypothesis: Immediately downstream of the Life deluxe chlorine/bromine chlorinator, I expect to find no *E.* coli and as the Dainfern Estate has adequate sanitation facilities, I expect that level to remain low throughout the Estate.

Design/Justification of Method of Inquiry

I am starting my measurements above the chlorinators to gain an understanding of how prevalent the *E*. coli is before it reaches the chlorinators and then I will measure at set distances downriver from the chlorinators where there is easy access to the river. The following map (figure 1) shows where the chlorinators are located, as well as the locations where I will be taking samples. My dependent variable is how I will measure/test the water samples. I will be using the Somerset Coliform tablets to test the water. I chose to use these tablets because they are readily available, cheap, very simple to use and give a result within 48 hours. My controlled variables are measuring at the same point and depth of the river, as well as collecting as little debris as possible from the bank of the river.

Figure 1: Locations in which I will collect samples and location of Life chlorinators.



Materials:

Items	Photo
Microbiology *E.* coli test package from Somerset (50 tablets)	
50 water bottles used for water collection (250 ml each) - *water bottles will not be filled completely*	
Dis-chem medicine dropper (3 ml)	
Makro Gardening Gloves (rubber gloves to protect against the water)	
Disposable masks from Makro	
UV light for coliform testing	
2 50 ml measuring flasks	
Scientific: Series 2000 Incubation Machine	

Method

1. Collect 10 samples of 15 ml per location on figure 1. Samples will be collected on the left bank (downstream pov) at 3 inches under the surface.
2. My sampling will be done over two days, and will likely take about 3-3.5 hours.
3. Add 10 ml of water to each of the somerset coliform tests, being careful not to disturb the tablets.
4. The tubes will be labeled by site, then I will leave the test kits to incubate at 27 degrees celsius for 48 hours.
5. After the 48 hours, if the gel is orange, water is negative of *E.* coli. However, if the gel is yellow, then the water is positive.

Safety, Ethics and Environmental Issues

I collected water samples that potentially contained *E*. coli, so I took precautions to ensure that I did not get sick in the process. I used plastic watertight gloves from Makro to prevent the water from getting on my hands. I was driving a car to each site and could have easily spread germs all over the steering wheel, seats and doors, so this was an important measure. After each sample, I put the gloves into a plastic bag which was isolated from everything else. In addition, I sanitized my hands frequently. Another safety precaution I took was wearing a mask at all times. This ensured that no water would splash into my mouth or onto parts of my face. When I brought the samples to school, I kept them sealed for transport and I made sure to wear a mask and gloves at all times. On top of this, when handling the samples at school I wore a lab coat which I removed when I was done working with the samples to help prevent any germs coming in contact with various school equipment. After my testing and sampling, I used hot water and soap to wash my hands for about 1.5-2 minutes. I also washed my equipment, including water bottles and gloves. I left my lab coat with the school to get washed in hot heat and soapy water. After the data collection and all my tests were complete, I left the water samples with the school since they have an external company who comes to the school and collects the hazardous waste. From there, the water was taken to a plant where it was frozen, then incinerated.

<u>Data Presentation</u>

Table 1: Raw data from Site 1

Collection Site 1	*E.* coli Present	*E.* coli Absent
Sample 1	✓	
Sample 2	✓	
Sample 3	✓	
Sample 4	✓	
Sample 5	✓	
Sample 6		✓
Sample 7		✓
Sample 8		✓
Sample 9		✓
Sample 10		✓

Table 2: Raw data from Site 2

Collection Site 2	*E.* coli Present	*E.* coli Absent
Sample 1	✓	
Sample 2	✓	
Sample 3	✓	
Sample 4		✓
Sample 5		✓
Sample 6		✓
Sample 7		✓
Sample 8		✓
Sample 9		✓
Sample 10		✓

Table 3: Raw data from Site 3

Collection Site 3	*E.* coli Present	*E.* coli Absent
Sample 1		✓
Sample 2		✓
Sample 3		✓
Sample 4		✓
Sample 5		✓
Sample 6		✓
Sample 7		✓
Sample 8		✓
Sample 9		✓
Sample 10		✓

Table 4: Raw data from Site 4

Collection Site 4	*E.* coli Present	*E.* coli Absent
Sample 1	✓	
Sample 2	✓	
Sample 3	✓	
Sample 4		✓
Sample 5		✓
Sample 6		✓
Sample 7		✓
Sample 8		✓
Sample 9		✓
Sample 10		✓

Table 5: Raw data from Site 5

Collection Site 5	*E.* coli Present	*E.* coli Absent
Sample 1	✓	
Sample 2	✓	
Sample 3	✓	
Sample 4	✓	
Sample 5	✓	
Sample 6		✓
Sample 7		✓
Sample 8		✓
Sample 9		✓
Sample 10		✓

Percent Present and Absent at each site

Site	Percent Present (%)	Percent Negative (%)
1	50%	50%
2	30%	70%
3	0%	100%
4	30%	70%
5	50%	50%

Chart 1: Percent Present and Absent at Site 1

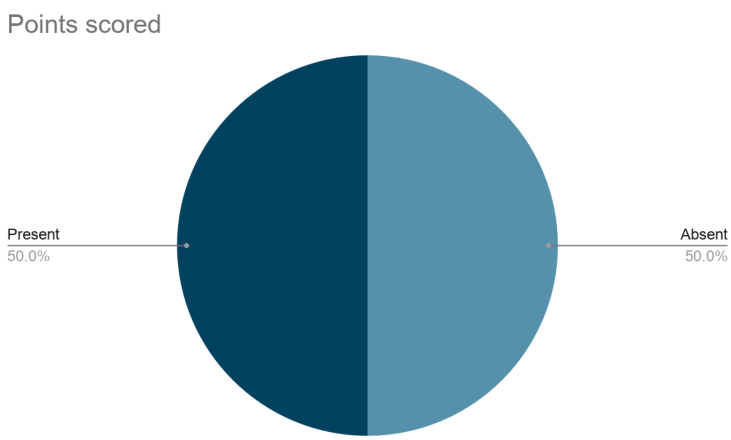


Chart 2: Percent Present and Absent at Site 2

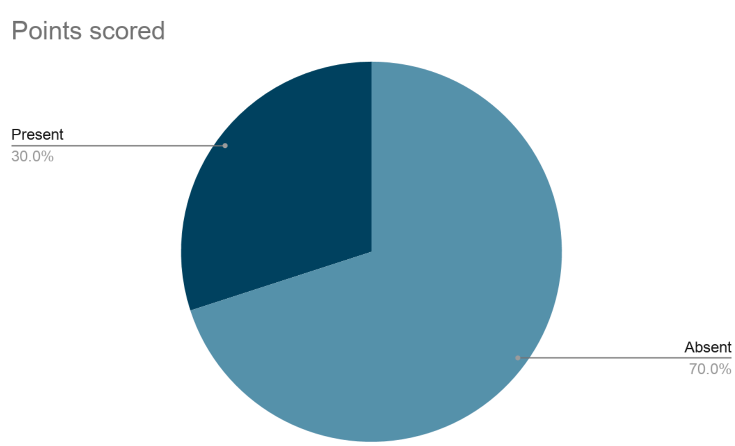


Chart 3: Percent Present and Absent at Site 3

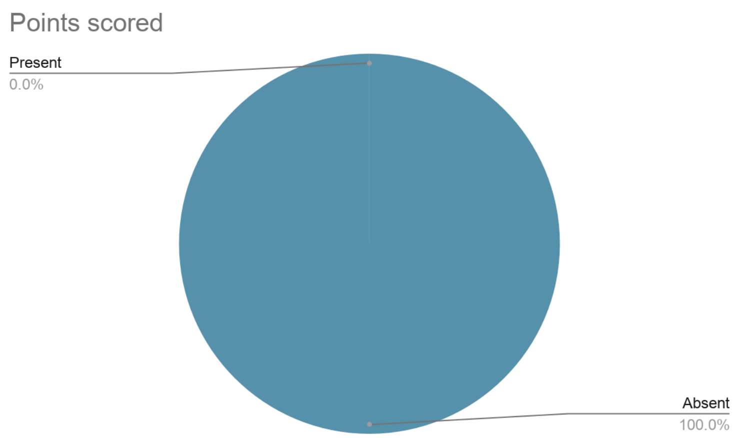


Chart 4: Percent Present and Absent at Site 4

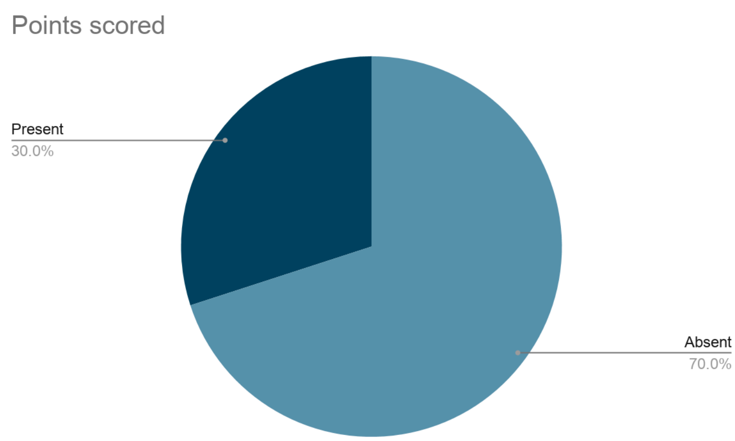
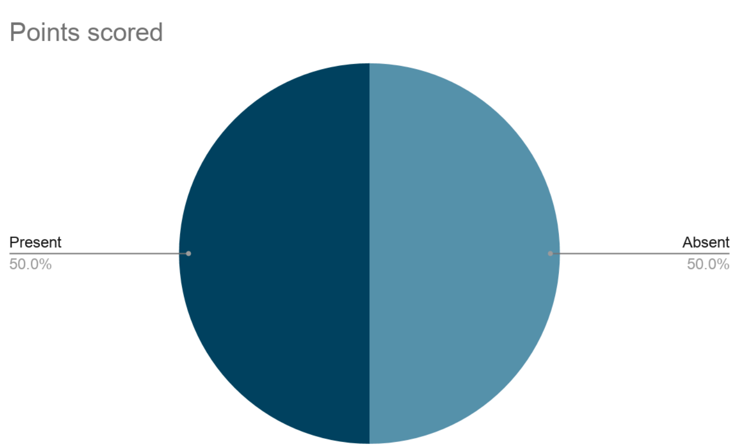


Chart 5: Percent Present and Absent at Site 5



Data Processing and Analysis

For every site I took the samples at 3 inches under the surface, and from the left bank of the river. At site 1 we see that 5/10 samples were positive and 5/10 were negative. Of the 10 samples at site 2, 3/10 were positive and 7/10 were negative. Site 3 showed 10/10 samples negative, which was expected because of the chlorinators. Site 4 was the same as site 2, 3/10 were positive and 7/10 were negative. At site 5, 5/10 were positive and 5/10 were negative.

Conclusion

My original hypothesis was proven incorrect, as shown in the raw data tables and pie charts, because although the presence of *E.* coli decreased immediately downstream from the Life chlorinators it did not remain low through the remainder of the Dainfern Estate. The presence of *E.* coli was the same entering the Dainfern Estate as it was leaving it, which lessens the impact of the chlorinators. This tells us that *E.* coli is being introduced into the river somewhere downstream from the Life chlorinators. This could be the result of a break or leak in the sanitation system inside the Dainfern Estate or there may be some other source of *E.* coli.

Discussion of Conclusion

The fact that the presence of *E.* coli in the river water leaving a wealthy community where every house has a flush toilet and is connected to a sanitation system is the same as the river water leaving a low-income community where many people do not have access to running water or toilets is troubling. This suggests that the destructive environmental impact caused by sewage contaminating rivers cannot be solved simply by giving people access to toilets and sewage systems. While providing these things will certainly improve lives and should be a high priority, the effort to protect the environment cannot stop there. We also need to ensure that the systems that are capturing the sewage are not intentionally or unintentionally releasing it back into the environment.

Strengths and Limitations of the Method

The test kits I used were binary which means there were only 2 outcomes: positive or negative. If I had a testing method that had more sensitivity and could measure the actual level of *E.* coli, then I would have been able to gain a better understanding of the concentration in the river. There is also a question of reliability since many of my original samples showed a false positive. Before the December break all my samples were positive, but during the break many of them changed to negative, which required me to re-collect the samples and run the tests again.

Improvements and Extension

Improvements that I could have made to my research include timing the weather better. One time that I collected the samples, it was raining and the river was a lot higher on the banks and a lot choppier. The second time I went, the water levels were much lower and the water was flowing quite slowly. This could have affected the amount of debris that got into my water samples. However, to reduce the likelihood of debris/contamination I washed the water bottles out a couple of times at each site with the water from the river.

Potential Application

The results of my investigation show that the Life chlorinators do in fact reduce the presence of *E.* coli. I saw this at Site 3 when all samples were negative of *E.* coli. From there, however, the amount of samples with *E.* coli present increased to the point that the presence of *E.* coli in the river exiting the Dainfern Estate was the same as entering the Estate. Possible solutions to this could be buying more advanced chlorinators and running more tests in the river. The Life chlorinators seem to be effective, but they are not able to filter all the water that flows through the area. Another possible solution would be for the Dainfern Estate to hire professionals to inspect the Estate and find out whether there are any leaks or breaks in the sanitation system that is allowing sewage to flow back into the river or, if not, to identify whether there is some other source of *E.* coli. If the Dainfern Estate is able to eliminate the presence of *E.* coli in the Jukskei River throughout the Estate, then other Dainfern Estates could adapt similar techniques to clean up their portions of the river as well.

Evaluation of Application

The solutions outlined above would be effective in finding out where the pollution from the Dainfern Estate is coming from, as well as how to stop it. However, we have to ask: who would pay for these solutions? It is unlikely the government would do so because there is limited value in cleaning up this one small section of the river, particularly for a wealthy community, other communities have more pressing needs. It also seems unlikely the residents would want to pay for this as finding out how *E.* coli is being introduced back into the river and taking steps to address the issue is likely to be much more expensive than adding the chlorinators. I think at a minimum it would be worth the investment for the Dainfern Estate to hire professionals with more experience and better equipment than I have to do an analysis and find out if in fact the *E.* coli levels leaving the Dainfern Estate are the same as entering the Estate. In addition, continued studies should be done to make sure that adding these levels of chlorine and bromine to the environment are not having an adverse impact.

Work Cited

1. Gatesfoundation.org. 2021. *Water Sanitation and Hygiene*. [online] Available at: https://www.gatesfoundation.org/What-We-Do/Global-Growth-and-Opportunity/Water-Sanitation-and-Hygiene

2. Zaynetdinova, M., 2018. *Poor Sanitation Practices are 'The Greatest Nightmare of Africa'*. [online] Global Citizen. Available at: https://www.globalcitizen.org/en/content/open-defecation-rises-in-sub-saharan-africa/#:~:text=Often%20called%20%22the%20greatest%20nightmare,Health%20Organization%20and%20UNICEF%20estimate.

3. Randwater.co.za. 2021. *Water Pollution*. [online] Available at: https://www.randwater.co.za/CorporateResponsibility/WWE/Pages/WaterPollution.aspx#:~:text=inadequate%20sewage%20collection%20and%20treatment%3B&text=Increase%20in%20fertilizers%20to%20grow,the%20oxygen%20in%20the%20water.

4. Hoyle, B., Lerner, K. and Richmond, E., 2021. *Algal Blooms in Fresh Water - river, algae, freshwater, effects, important, salt, system, plants, source*. [online] Waterencyclopedia.com. Available at: http://www.waterencyclopedia.com/A-Bi/Algal-Blooms-in-Fresh-Water.html#:~:text=Some%20algae%20produce%20toxic%20chemicals,often%20toxic%2C%20are%20the%20cyanobacteria.

5. Bega, s., 2018. *Jukskei: it’s not a sewer, it’s a river*. [online] Iol.co.za. Available at: https://www.iol.co.za/saturday-star/news/jukskei-its-not-a-sewer-its-a-river-16501822