Investigating fish population density in school ponds

Planning

Introduction

Raising fish in captivity as a source of food is an increasingly common alternative to wild-catch fishing. It is important to understand how the different parts of an aquaculture ecosystem interact in order to provide a safe and sustainable environment for the fish to live.

CXT: Fish farming is a relevant environmental issue but there is no detail provided indicating that the student understands it.
What should be included is reference to decreasing wild fish stocks, increasing demand for protein by an increasing global population. The lack of a well-defined environmental issue makes it very difficult for a student to show a link between the research question and the issue, and so the score poorly on both of these.

A pond is a small-scale local ecosystem that can be used as a model for a larger aquaculture ecosystem. In this investigation, I will investigate the relationship between fish population density and two abiotic factors in two ponds in my school grounds. The small volume of the ponds are models of bigger-volume ponds in an assumption that the input, output, transfer and transformation in both small- and big-volume ponds are about the same.

The abiotic factors that I will investigate are pH (acidity or alkalinity) and amount of total dissolved solid (TDS). In both, the species of fish present is koi carp, *Cyprinus carpio*.

Fish excretion contains ammonia, which is an alkali. Another main source of ammonia is the dead algae in the bottom of the pond, which diffuses from the sediment into the water column. Ammonia may influence the pH and TDS that are contained in water. Therefore, there could be a relationship between fish population density and pH and TDS.

Research question

What is the relationship between fish population density and pH or total dissolved solid (TDS) in two different human-made ponds that surround the chapel of my school?

CXT: The research question is focused but not very relevant.

Hypothesis

I hypothesize that the pond with the higher fish population density will have higher pH and higher TDS (positive correlation between three variables).

It is because a pond with higher fish population density will contain more ammonia. The higher the ammonia, the higher the pH and TDS because ammonia is an alkali.

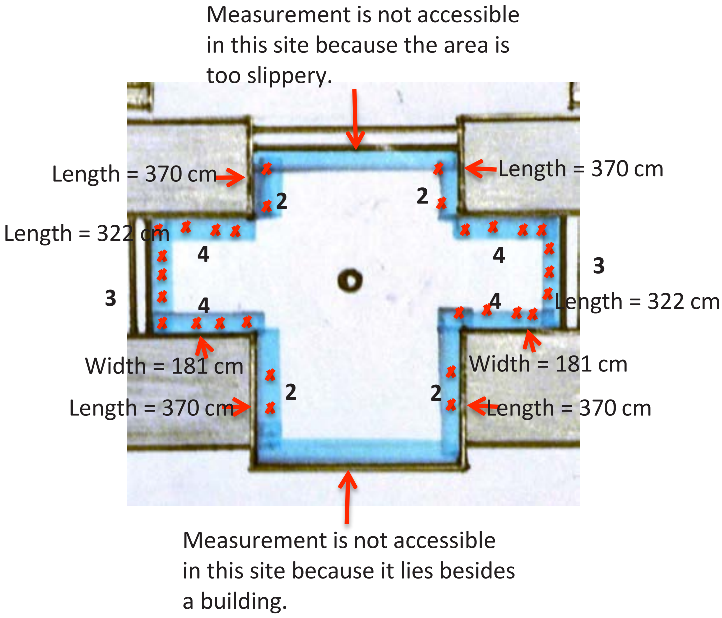
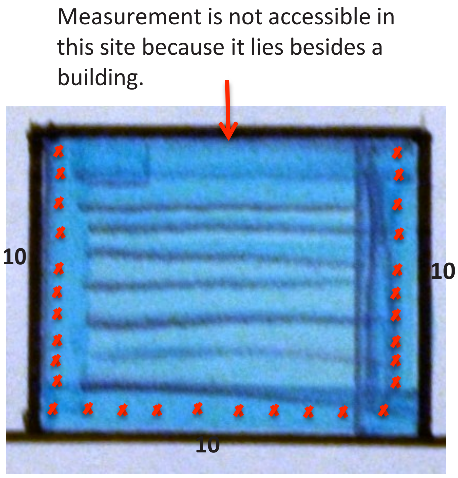
Independent variable

The independent variable is fish population density.

Dependent variable

The dependent variables are pH and TDS.

Controlled variables

No.	Controlled variable	How to control
1	Distance between sampling sites in each pond.	It is controlled by stratified sampling method. **<u>Picture to show the sampling sites of Pond A</u>**  **<u>Picture to show the sampling sites of Pond B</u>** 

PLA: This is a statement, but not a justification of the sampling strategy.

PLA: The distance between sampling sites is not given and there are no samples taken in the middle of the ponds. The aeration of Pond A at least may have a significant mixing effect, and the shape of both ponds means that sampling along the edges will not provide representative samples. Also, when looking at the dimensions of Pond A and the number of samples taken, it would appear that some edges are over-sampled compared to others.

2	Depth of pond in which pH and TDS are measured.	I dipped the pH indicator strip and the conductivity probe 3 cm below the water surface.
3	Number of samples taken.	I took 30 trials for each pond.
4	Time of day.	Data was collected at about the same time of day.

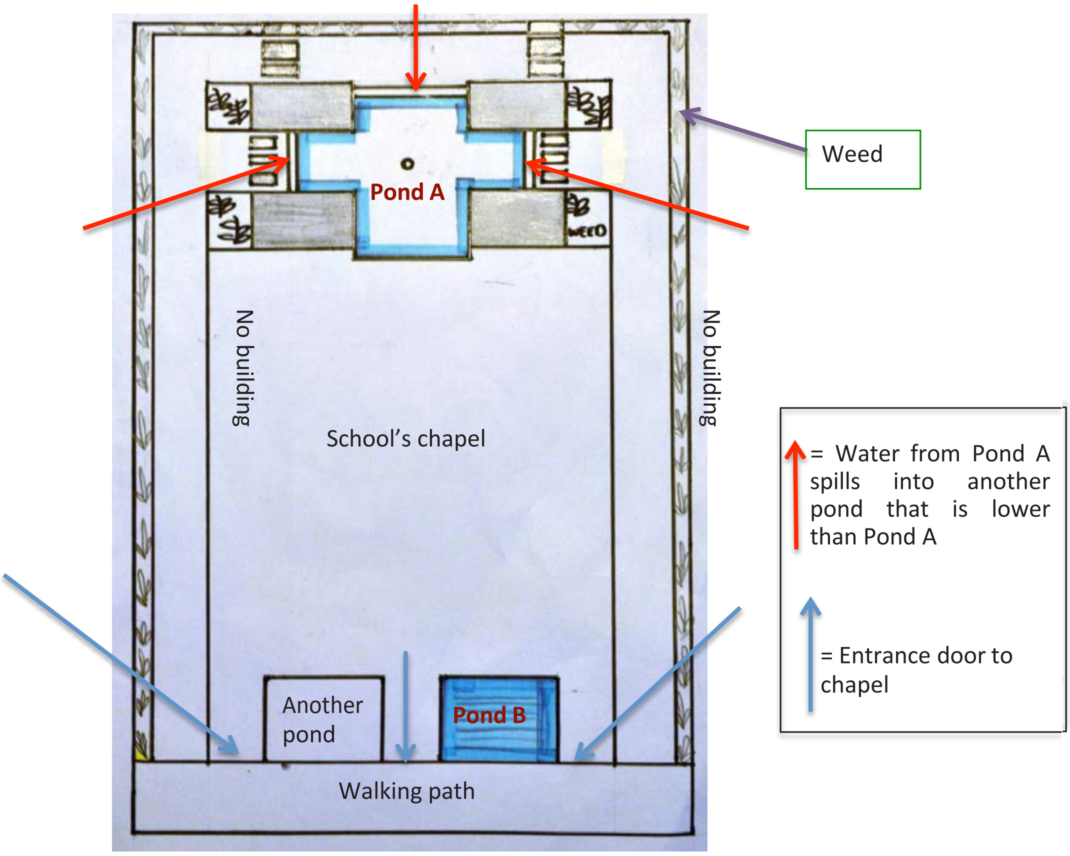
Variables that could not be controlled

1. Amount of vegetation that surrounds the ponds.
2. Amount of dead algae or any other organic matter in the ponds.
3. The presence of pumps and filters: Pond A had an air pump but no filter. Pond B had only a mechanical filter (see pictures below).

Picture to show Pond A (author's own)

Picture to show Pond B (author's own)

Hand-drawn sketch map to show location of Pond A and Pond B



Method

1. Count the number of fish that occupy each pond.
2. Use pH indicator strips to measure the pH of the pond 3 cm below the surface and at 30 different places around the ponds.
3. Use a conductivity probe to measure the TDS 3 cm below the surface and at 30 different places around the pond. Ensure that the probe is correctly calibrated and rinse with distilled water between each measurement.
4. Measure volume of the ponds by recording all the dimensions of each pond with a 90 cm stick. Record the number of stick lengths for the depth and the length of all the sides, and use a measuring tape to convert the stick lengths into cm.

Data collection and processing

Raw data

Number of fish population

Pond A = 24 fish

Pond B = 53 fish

Table 1 to show the pH levels in Pond A and Pond B

Number of trial	pH in Pond A (pH)	pH in Pond B (pH)
1	6	6
2	7	6
3	6	6
4	6	6
5	6	6
6	6	7
7	7	7
8	6	6
9	6	6
10	6	6
11	6	6
12	6	6
13	8	7
14	6	6
15	6	6
16	6	6
17	8	6
18	6	7
19	6	7
20	6	6
21	7	6
22	6	6
23	6	6
24	6	6
25	7	6
26	6	6
27	6	6
28	7	7
29	6	6
30	7	6

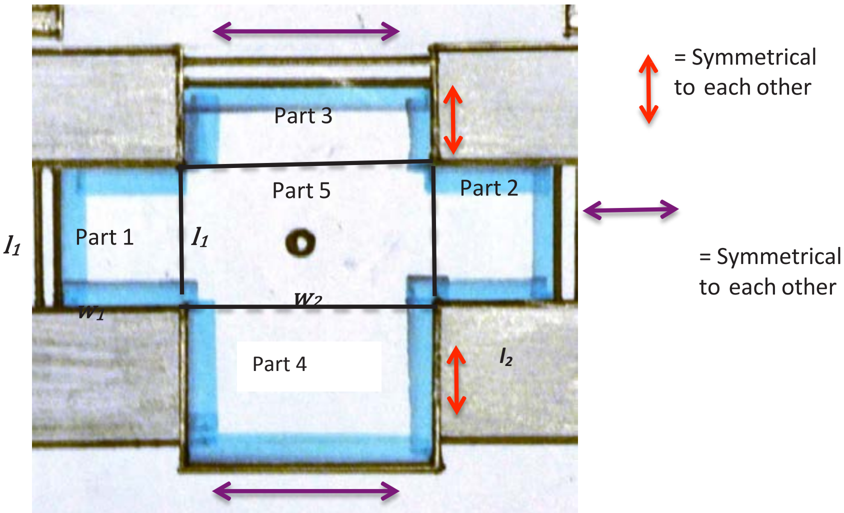
Table 2 to show the amount of TDS in Pond A and Pond B

Number of trial	TDS in Pond A (mg/L ± 0.1 mg/L)	TDS in Pond B (mg/L ± 0.1 mg/L)
1	76.7	75.5
2	76.6	75.5
3	76.7	75.6
4	76.6	75.6
5	76.6	75.7
6	76.5	75.6
7	76.4	75.5
8	76.5	75.5
9	76.5	75.8
10	76.4	75.7
11	76.5	75.8
12	76.5	75.7
13	76.4	75.8
14	76.6	75.9
15	76.5	75.9
16	76.6	75.9
17	76.7	76.0
18	76.7	75.9
19	76.7	75.6
20	76.8	75.7
21	76.7	75.8
22	76.6	75.5
23	76.7	75.6
24	76.6	75.9
25	76.6	75.9
26	76.6	75.8
27	76.6	75.6
28	76.6	75.8
29	76.6	75.9
30	76.5	75.6

Measurements for calculating volume of Ponds A and B

Pond A

Picture to show that in order to measure the volume of Pond A, Pond A is divided into five



The following data are in cm units with uncertainty ± 0.1 cm.

Part 1 = Part 2

Length (l_1) = (3 x 90 cm) + 52.0 cm = 322.0 cm
Width (w_1) = (2 x 90 cm) + 17.0 cm = 181.0 cm
Depth (d_1) = 61.0 cm

RAC: Calculation error.

Part 3 = Part 4

Length (l_2) = (4 x 90 cm) + 10.0 cm = 370.0 cm
Width (w_2) = (1 x 90 cm) + 50.0 cm = 140.0 cm
Depth (d_2) = 64.0 cm

Part 5

Length (l_1) = (3 x 90 cm) + 52.0 cm = 322.0 cm
Width (w_2) = (1 x 90 cm) + 50.0 cm = 140.0 cm
Depth (d_2) = 64.0 cm

Pond B

Length = (4 x 90) + 72.0 cm = 432.0 cm
Width = (2 x 90 cm) + 81.0 cm = 261.0 cm
Depth = 88.0 cm

Qualitative observations

- Pond A has more alive green algae than Pond B.
- Both Pond A and Pond B have fish excretion in the pond's bed.
- Pond B is more disturbed by humans than Pond A because Pond B is right beside a walking path and entrance doors of the chapel. The location of Pond A is at the back of the chapel and people rarely go there.
- Water in Pond A has more oxygen than Pond B because there is a water and air pump, which moves water through the filter system and back to the pond. Pond B only has a mechanical filter, which traps solids in the pond but does not add air.
- Water in Pond A spills over to another, lower, pond. In Pond B the water in the pond stays unless the water is drained.
- Both Pond A and Pond B are human-made.
- Fish in Pond B seem to swim in the surface while fish in Pond A relatively do not swim in the surface. The fish in Pond B seem more crowded.
- The fish in both ponds swim fast, which makes the fish-counting process hard.

Processed data

Table to show mean of pH in Pond A and Pond B

Mean	
pH in Pond A (pH)	**pH in Pond B (pH)**
6.3	6.2

Table to show mean of TDS in Pond A and Pond B

Mean	
TDS in Pond A (mg/L ± 0.1 mg/L)	**TDS in Pond B (mg/L ± 0.1 mg/L)**
76.6	75.7

RAC: Although error bars are placed on the graphs, there is no evidence of the calculation of standard deviations or standard errors.

Volume of Pond A

Part 1 and Part 2

Volume = 2 x (l_1 x w_1 x d_1)

= 2 x (322 cm x 181 cm x 61 cm)

= 2 x 3,555,202 cm^3

= 7,110, 404 cm^3

$= \frac{7,110,404}{1000}$ dm^3

= 7,110.4 L

Part 3 and Part 4

Volume = 2 x (l_2 x w_2 x d_2)

= 2 x (370 cm x 140 cm x 64 cm)

= 2 x 3,315,200 cm^3

= 6,630,400 cm^3

$= \frac{6,630,400}{1000}$ dm^3

= 6,630.4 l

Part 5

Volume = l_1 x w_2 x d_2

= 322 cm x 140 cm **x** 64 cm

= 2,885,120 cm^3

$= \frac{2,885,120}{1000}$ dm^3

= 2,885.1 l

Therefore, **total volume of Pond A** is = 7,110.4 L + 6,630.4 L + 2,885.1 L

= 16,625.9 L

Volume of Pond B

Volume = $l_3 \times w_3 \times d_3$

= 322 cm x 261 cm x 88 cm

= 7,395,696 cm^3

$= \frac{7,395,696}{1000} \ dm^3$

= 7,395.7 l

Therefore, **total volume of Pond B** is **7,395.7 L**

Fish population density of Pond A

Fish population density = $\frac{\text{Fish population (fish)}}{\text{Volume of pond (L)}}$

$= \frac{24}{16,625.9}$

= 0.00144353 fish/l

= 1.44×10^{-3} fish/l

Fish population density of Pond B

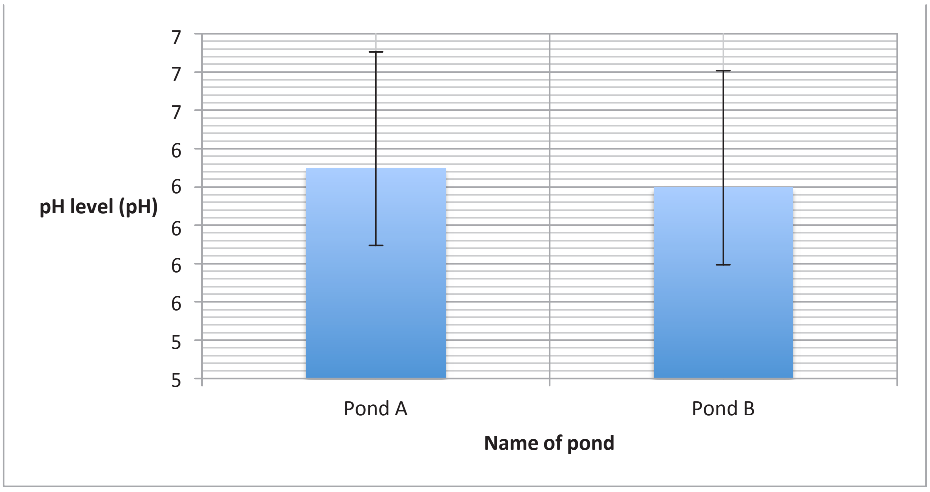
Fish population density = $\frac{\text{Fish population (fish)}}{\text{Volume of pond (L)}}$

$= \frac{53}{7,395.7}$

= 0.00716633 fish/L

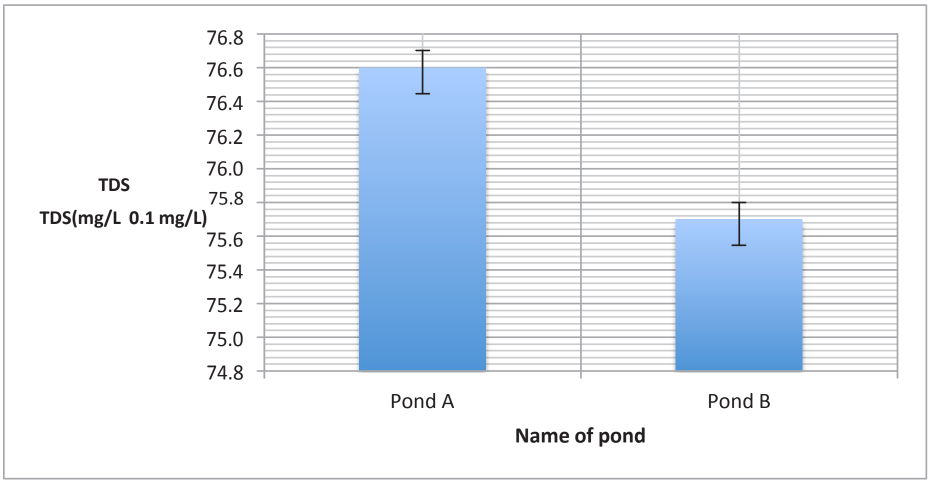
= 7.16×10^{-3} fish/L

Graph 1: Showing the comparison in pH level between Pond A and Pond B



RAC/COM: The vertical axis on this graph is confusing. It appears that decimals have been removed and it should read 6.0, 6.2, 6.4, etc.

Graph 2: Showing the comparison in total dissolved solid (TDS) level between Pond A and Pond B



Discussion, evaluation and conclusion

Discussion

The fish population density in Pond B is higher than the fish population density in Pond A. The mean pH level in Pond A is greater than the mean of pH level in Pond B but, looking at the error bars, this difference is not significant. The mean of TDS in Pond A is greater than the mean of TDS in Pond B.

The ideal pH for koi fish is 7.4 but koi will do quite well in water ranging from 7.0 to 9.0 as long as it does not fluctuate too much. Since my result of pH is below 7, it means that the water in the two ponds is too acidic for koi fish and it may burn their skin. Moreover, another source shows that a level of TDS of 400 ppm (400 mg/L) or less is recommended for koi. My results do not match this because the mean of TDS for Pond A is 76.6 mg/L or 76.6 ppm while for Pond B is 75.7 mg/L or 75.7 ppm.

COM: The student has not indicated which publication in the bibliography contains this information.

DEV: This is incorrect—results do match the source (which also does not seem to be correctly referenced), that is, the results **are** below 400 ppm.

pH swings are very dangerous for koi fish as they interfere with basic body functions, leaving fish vulnerable to stress and disease. According to Hanna Meters website (1), *"changes in the amounts of dissolved solids can be harmful because the density of total dissolved solids determines the flow of water in and out of an organism's cells. Concentrations that are too high or too low may limit the growth of koi and will lead to death. The greater the amount of solids in the water versus the solids in the tissue of the fish will also result in a fluid loss via the gills."*

Evaluation

DEV: The lack of environmental context at the outset continues to have a knock-on effect. As there is no environmental context, the student has difficulty evaluating the conclusion in this context.

There are a number of factors that should be taken into account here. Firstly, it was difficult to accurately count the number of fish because the fish look similar, they swim really fast and some of them may swim in the pond's bed. Secondly, I did not measure the pH and TDS in the middle of both ponds and there might have been different readings in these places. Also, pH may swing, especially between day and night, because at night plants give off CO_2, which may decrease the pH, while in the day plants absorb CO_2, which may increase the pH.

The ponds had different types of filters and this was a problem because there were abiotic factors, such as dissolved oxygen, that were not controlled. This could have affected the fish population density because fish need oxygen in the water to live.

DEV: Some weaknesses are described but not discussed.

To solve some of these problems I could use a stick or a rod to take pH and TDS readings in all parts of the ponds, including the middle. I could use a pH probe rather than pH paper to get more accurate readings of pH, and I could take readings at different times of the day, or even on different days over a time period of two weeks. It would not be easy to solve the problem of the different pumps.

Comment [A12]: DEV: There are modifications suggested.

Conclusion

I conclude that by just looking at the absolute values, Pond A, which has lower fish population density, has greater pH and TDS than Pond B. I conclude that actually there is no significant difference in pH level and only a small difference in TDS between Pond A and Pond B. This rejects my hypothesis that the pond with a higher fish population density will have higher pH and higher TDS.

13

My conclusion is supported by my results, which shows that Pond A's fish population density is 1.44 x 10^{-3} fish/l, while the fish population density of Pond B is 7.16 x 10^{-3} fish/l. Graph 1 shows that the mean of pH level of Pond A is 6.3, while the mean of Pond B's pH level is 6.2. Graph 2 shows that the mean of Pond A's TDS is 76.6 mg/L while the mean of TDS of Pond B is 75.7 mg/L.

One possible explanation for this is that both ponds are human-made. This is shown by the presence of filters. Because Pond B has a mechanical filter and Pond A does not, the mechanical filter in Pond B may trap the dissolved solids, thus the TDS in Pond B is lower than Pond A.

Comment [A13]: RAC: The conclusion is valid and the student recognizes that the differences in the pH data are quite small and may not be significant. The student could have looked at standard deviations and indicated that the degree of overlap between these bars was a further indication that the differences were probably due to random chance. TDS, however, does look significantly different and, although this is not mentioned, an explanation for this difference is offered.

Applications

Although my investigation did not give a solid result, it is important to know how abiotic factors such as pH and TDS are related to fish population density. It would be interesting to set up about five ponds stocked with fish, and do experiments to see what happens to the pH when the fish population changed. This might be seen as unethical because some pH levels could kill fish, but on the other hand it might be important to help fish farmers to know exactly how to raise fish in ideal conditions so they grow well and produce food for the human population. These days, fish farming is needed as an alternative to sea or river fishing because stocks of fish have been fished unsustainably and the fish are becoming endangered.

Comment [A14]: DEV: Further areas of research are mentioned here.

Comment [A15]: APP: An application is stated and some implications are mentioned.

Word count: 2702

Comment [A16]: COM: The report is easy to read, well-structured and organized. Terminology use is appropriate.

References

(1) www.hannameters.co.uk/pages/Hanna_TDS_Meter? on 13 June 2012

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