WALKING ON WATER: WHAT AFFECTS SURFACE TENSION?

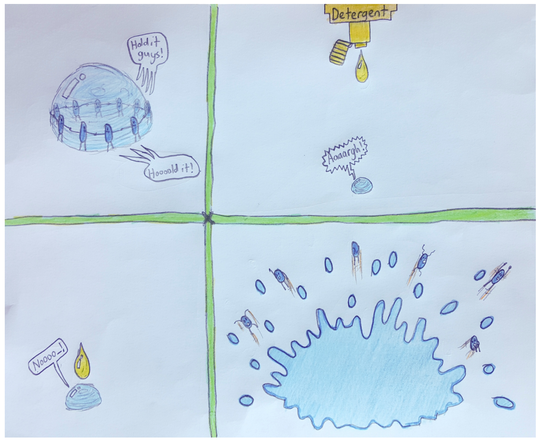
INTRODUCTION

In this experiment I will be looking at the effect on surface tension when increasing temperature and adding paint, petrol and detergent.

BACKGROUND

Water molecules are electrically charged particles. This causes them to stick to the surrounding molecules but the net effects of the molecules pulling on each other cancel out. On the surface there are no molecules to stick to above so it increases the cling on the molecules around it. This makes the outer layer like a skin and makes it able to hold objects much heavier than itself. This is surface tension.

Some examples of surface tension being exploited are the Water Strider spider and the Basilisk lizard (also nicknamed the Jesus Christ lizard) which can both walk on water. Similarly needles and paperclips can float even though they are heavier than water. Water droplets also 'sit' on a surface as a sphere. This is because of the outer layer pulls the droplet together into a sphere to stop it spilling everywhere. When you put cleaning liquid or detergent in water it reduces the surface tension. This means it is better to clean clothes because the water can soak into dirty sections easier. However, cleaning agents may leak into waterways and harm animals ability to use surface tension to their advantage.



METHOD

Apparatus:

In order to measure surface tension I made a measuring device (see Figure 1). It consists of a balance made by two big plastic cups on the sides and a straw held through the middle by a needle. On one side a flat piece of tin was suspended by dental floss on the surface of a cup of water. On the other side was a counterbalance consisting of a plastic bottle cap in which weight in the form of rice was placed.

Care was taken to minimise friction at the pivot of the balance and that the balance was as lightweight as possible. This was to make sure it could detect the slightest change in weight/force. The distance from the pivot point to the line of pull for the piece of tin (surface tension force) and the bottlecap (counterweight) was carefully measured to be the same. This ensured that whatever the pull of surface tension was matched by the weight in the bottle cap.

A 3 cm x 3 cm* piece of tin (attached to the straw by floss) was used to measure the surface tension. This was selected because it was very smooth to maximise contact with the water. A piece of putty was used to ensure the straw was balanced. A cup of water was placed under the tin so it floated and the floss was taught.

* Initially a 1 cm square piece of tin was chosen but after some testing it was decided that a larger surface area was more desirable as the difference between weight measurements (described below) would be larger and so more detectable.

Scales and temperature probe

Experiment:

The first part of the experiment measured the effect of temperature change and the second part of adding common pollutants (detergent, petrol and paint) that can leak into waterways. Because changes in surface tension happen on a very small scale I decided to use single grains of rice as my weight increment. I discovered that the average grain of rice weighed approximately 0.015 grams.

For a range of water temperatures rice was added (one by one) to the bottlecap, leaving approximately 2-3 seconds between each grain until the tin got lifted off the water. I then weighed the rice and wrote down the weight and number of grains in a table. The weight was considered to equal the force of surface tension. Between tests I ensured conditions were kept the same by drying the bottom of the tin (no extra weight) and the water level for each temperature was equal.

For the second part I added different pollutants to the water in amounts of 1 drop, 5 drops, then ten drops and the weighting procedure (above) was then repeated for each. A new cup was used each time to avoid contamination and the water temperature kept the same.

ACKNOWLEDGEMENTS

I would like to thank my Mum and Dad for encouraging me and helping me understand my project and my teacher Mr Pickles for lending me an electrical thermometer and scales.

REFERENCES

http://www.wikihow.com/Measure-Surface-Tension,
https://water.usgs.gov/edu/surface-tension.html,
Various youtube videos that showed me how to make my apparatus

HYPOTHESIS

From what I have read this is what I expect from my experiment:

1: the hotter the water gets, the less surface tension it will have.

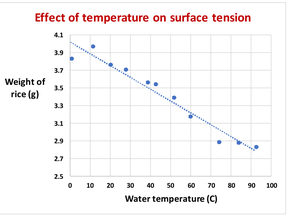
2: detergent, petrol and paint - common products- that end up in the environment will all decrease the surface tension of the water.

RESULTS

No. Grains	Weight	Average per grain
275	4.07 g	0.0148 g

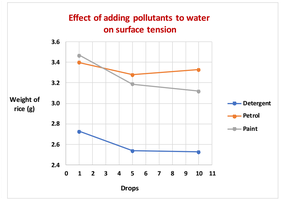
The table above shows the average weight of a grain of rice. These particular grains of rice were used in our experiment.

Temp (deg C)	grains of rice	weight of rice (g)	% change from 20.1 deg C
0.6	255	3.83	1.9%
11.2	275	3.97	5.6%
20.1	262	3.76	0.0%
27.6	258	3.71	-1.3%
38.4	246	3.56	-5.3%
42.5	243	3.54	-5.9%
51.4	236	3.39	-9.8%
59.6	222	3.18	-15.4%
73.8	203	2.89	-23.1%
83.5	195	2.88	-23.4%
92.3	192	2.83	-24.7%



The results of the table above are shown in the first graph (above). The results shows that when the water temperature increased, the weight of rice decreased meaning the surface tension was lower. As the temperature went up approximately 10 deg. C the weight decreased by approximately 0.15 g (4%). A line of best fit was plotted through the data and this indicated that the weight decreased proportionately to the temperature. My hypothesis was proved correct! The lowest temperature (0.6 deg. C) was an exception because it didn't follow this trend. This weight was lower than the second coldest temperature (11.2 deg. C) by 0.17 g. The reason for this may have been that I put the cold water in the freezer before the experiment and, even though I sieved it, there was probably small ice particles holding up the tin.

		Detergent	Petrol	Paint
Temp (deg C)	Drops	weight of rice (g)	weight of rice (g)	weight of rice (g)
20.3	1	2.7	3.4	3.5
20.3	5	2.5	3.3	3.2
20.3	10	2.5	3.3	3.1
		% change from 20.1 deg C water		
20.3	1	-27.4%	-9.6%	-7.7%
20.3	5	-32.4%	-12.8%	-15.2%
20.3	10	-32.7%	-11.4%	-17.0%



When I added the different pollutants (detergent, paint and petrol) I kept the water temperature at room temperature (20.3 deg. C). Compared to the room temperature water (20.1 deg. C, not noticeably different to 20.3) the surface tension was considerably less (measured by the weight of rice) when I added one drop of detergent (by 1.03 g, 27.4%).

CONCLUSION

Adding heat to water decreased the surface tension as did adding the pollutants (detergent, paint and petrol). Therefore, my hypothesis was proved correct.

When 1 drop of petrol and paint was added there was also a decrease in surface tension but not as great an effect as detergent, with petrol lowering surface tension more than paint (9.6%, 7.7% respectively). When I added 5 drops the weight needed to counterbalance decreased by much less- about 0.2 g but when I added 10 drops it decreased by only about 0.02 g. Overall the change in temperature did not affect the surface tension as much as adding the three pollutants.

DISCUSSION

In my hypothesis I stated that I thought a number of factors would reduce surface tension such as the pollutants; petrol, paint and detergent and an increase in the temperature of the water. I have found these predictions to be correct (see results table).

The implications of my results are that when the conditions of a lake or waterway change the animals that walk or run on water (eg. the basilisk lizard or water strider) will find this more difficult.

We find much warmer water around thermal regions so these animals might not be able to exploit surface tension as easily and so avoid these areas (apart from the fact that they might be uncomfortably hot).

When pollutants were added - traces of petrol, paint or detergent - the changes in surface tension were much greater than increasing the temperature. We should therefore be careful about what we let leak into drains, sinks and the environment because it may affect insects and animals that rely on surface tension to facilitate them accessing food or escaping from predators.

However, we do not know if the change in temperature will cause them to sink because in this study we have not tested the animals by weighing them or measuring their leg surface area. So we don't know if their suspension is finely balanced or if small changes will cause them to sink. This would be an interesting follow up study.

Because I found that both adding detergent and heating the water decreases surface tension this explains why it is better to clean clothes using detergent in warm water so that water more easily penetrates fabrics. Our results indicate the hotter the better.