Title – Salinity of tidal, estuary and river water

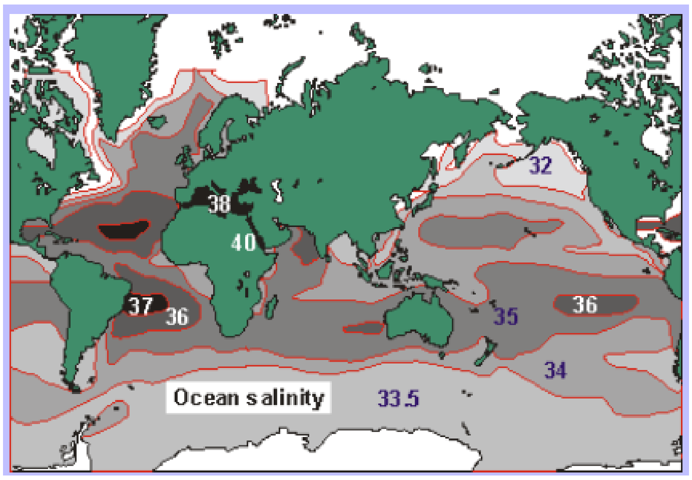
Aim

The aim of this investigation is to measure the salinity of water samples collected from different locations and compare them with the global average salinity of seawater, and to measure the chloride content of seawater

Underlying environmental science

Rainwater is naturally acidic, caused when carbon dioxide dissolves in moisture in the atmosphere to form carbonic acid. This breaks down rocks through chemical weathering, releasing ions that runoff into rivers and oceans. The most abundant ions in seawater are chloride, sodium, sulfate, magnesium, calcium and potassium, making up around 99% (1). These combine to form different salts, with sodium chloride the most common.

The more salts that are dissolved the more saline the water. The average global concentration of salt in seawater is around 3.5% (2) but the map below shows this varies around the world. The least saline seawater is found in parts of the Baltic Sea (around 0.5% salt content) but changes seasonally, getting saltier in the winter when sea ice forms and less salty when the sea ice melts and releases the freshwater again (3). The most saline is in the Red Sea (around 40% salt) where it is affected by high temperatures increasing the rate of evaporation, and also by very little freshwater entering from rivers (4).



Changes in ocean salinity patterns can be due to combinations of changes in ocean circulation, the hydrological cycle and the climate, and these are being affected by human activities. Global warming is making the north Atlantic Ocean slightly less salty because evaporation near the equator is increasing and the moisture in the atmosphere is being pulled towards the poles and falling as rain. This enters the rivers and seas as runoff and reduces the salinity, while ocean nearer the equator is left more salty (5)

This investigation will look at the salinity of tidal seawater, estuary water, and river water to see how they compare with the average global salinity of seawater. I will also assess the chloride content of seawater, which is what gives it its salty taste.

Method

Samples of water were collected from three locations: a beach, an estuary and a stretch of river above the tidal reach.

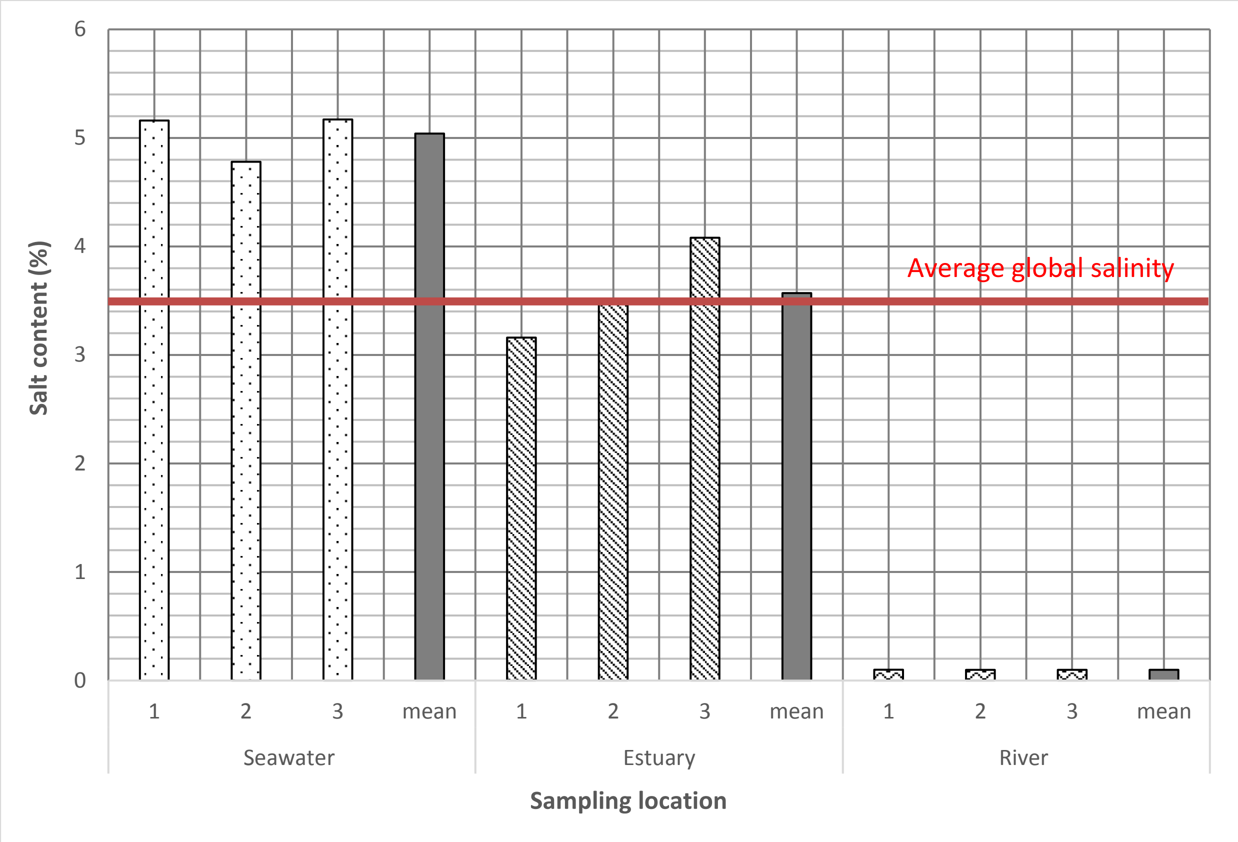
A 1 litre wide-mouthed bottle attached to a long pole was used to collect the water samples.

Experiment 1

We placed three samples from each bottle under a light bank. They were evaporated to dryness and then weighed to determine the salt in each sample.

Sampling location	Sample no	Mass of sample (g)	Mass of dried salt (g)	% salt in sample	Mean % salt
Beach	1	102.8	5.3	5.16	5.04
	2	102.5	4.9	4.78	
	3	102.5	5.3	5.17	
Estuary	1	104.3	3.3	3.16	3.57
	2	103.3	3.6	3.48	
	3	103.0	4.2	4.08	
River	1	100.3	0.1	0.0997	0.09897
	2	101.5	0.1	0.0985	
	3	101.3	0.1	0.0987	

The % salt content data is displayed on a bar graph.



Analysis of experiment 1

The average global salinity of seawater is around 3.5%. It can be seen that the beach sample has a much higher % salinity than this, and that the estuary sample is closer to the global value.

<u>Experiment 2</u>

A sample of the seawater from the beach was titrated with silver nitrate solution using the Mohr method. This determines the chloride content of the water.

Sample	1	2	3
Initial reading (cm^3)	0.0	11.1	22.2
Final reading (cm^3)	11.1	22.2	33.2
Volume of silver nitrate added (cm^3)	11.1	11.1	11.0

$$\text{Average volume used} = \frac{11.0 + 11.1 + 11.1}{3} = 11.07 \text{ cm}^3$$

Balanced equation:

$Ag^+ + Cl^- \longrightarrow AgCl$

Concentration of chloride ions:

- Seawater sample (A) = 10 cm^3, which was diluted to 100 cm^3 with distilled water and a 10 cm^3 sub-sample (B) was used for titration.
- Concentration of silver nitrate used = 0.05 mol l^{-1}
- Average volume of silver nitrate added = 11.07 cm^3

Moles of Ag^+ in volume of silver nitrate added = concentration x volume
= 0.05 mol l^{-1} x 0.01107 l
= 5.535×10^{-4} mol

Moles of Cl^- in (B) = 5.535×10^{-4} mol

Concentration of Cl^- in (B) = $\frac{5.535 \times 10^{-4} \text{ mol } l^{-1}}{0.01 \text{ l}}$ = 5.535×10^{-2} mol l^{-1}

Concentration of Cl^- in (A) = 5.535×10^{-2} x 10 = 5.535×10^{-1} mol l^{-1}

Concentration of Cl^- in original seawater
= 5.535×10^{-1} mol l^{-1} x RAM of chloride
= 5.535×10^{-1} mol l^{-1} x 35.5
= 19.65 g l^{-1}

<u>Analysis of experiment 2</u>

The concentration of chloride in the beach sample was found to be 19.65 g l^{-1}, which converts to 19,650 ppm. This compares well with the average global value of 19,345 ppm shown in the table below (3) and the table in the appendix shows that at 3.5% salinity the chloride content is 19,400 ppm.

chemical ion	valence	concentration ppm, mg/kg	part of salinity %	molecular weight	mmol/kg
Chloride Cl	-1	19345	55.03	35.453	546
Sodium Na	+1	10752	30.59	22.990	468
Sulfate SO4	-2	2701	7.68	96.062	28.1
Magnesium Mg	+2	1295	3.68	24.305	53.3
Calcium Ca	+2	416	1.18	40.078	10.4
Potassium K	+1	390	1.11	39.098	9.97
Bicarbonate HCO3	-1	145	0.41	61.016	2.34
Bromide Br	-1	66	0.19	79.904	0.83
Borate BO3	-3	27	0.08	58.808	0.46
Strontium Sr	+2	13	0.04	87.620	0.091
Fluoride F	-1	1	0.003	18.998	0.068

Conclusion

The beach sample should be almost all seawater. The estuary sample should be a mix of seawater and freshwater known as brackish water. The river sample was collected 25km upriver from the estuary so will be freshwater as the tide doesn't reach this far.

Experiment 1 showed that salinity falls as you move inland from the beach. The average global salinity of seawater is 3.5% but my estuary sample was closer to this value than the beach value was. The salts in the river sample were less than 0.1% and must have come from chemical weathering of rocks as the sample was collected a long way from the coast and so would not have been affected by seawater.

Experiment 2 assessed the chloride concentration of the seawater sample, which was found to be 19.65 g l^{-1}.

Evaluation

Care had to be taken not to place the light bank too close to the beakers as some of the sample could have sputtered out, removing salt along with the water and affecting the mass of total dissolved salts.

A salt crust formed as the water evaporated off and had to be broken up to allow the water below to evaporate. I used a glass rod and had to make sure not to lose any salt stuck to it. This also would have affected the mass of the total dissolved salts.

Determining the end point of the titration was tricky as there was no sharp change in colour. It took a lot of practice goes to work out what end point I should be looking for.

References

(1) https://www.britannica.com/science/hydrologic-sciences/Study-of-lakes#ref106214 accessed June 2018
(2) https://oceanservice.noaa.gov/facts/whysalty.html accessed June 2018
(3) http://www.seafriends.org.nz/oceano/seawater.htm#composition accessed June 2018
(4) https://www.sciencedaily.com/terms/seawater.htm accessed June 2018
(5) https://www.theguardian.com/environment/2008/oct/27/climate-change-water accessed June 2018

Appendix

The chemical composition of seawater at 3.5% salinity (3)

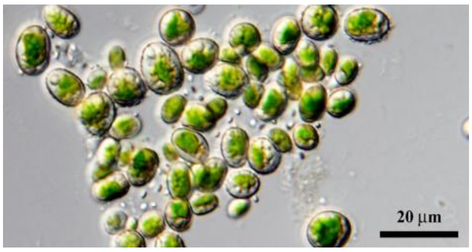
Element	At.weight	ppm	Element	At.weight	ppm
Hydrogen H2O	1.00797	110,000	Molybdenum Mo	0.09594	0.01
Oxygen H2O	15.9994	883,000	Ruthenium Ru	101.07	0.0000007
Sodium NaCl	22.9898	10,800	Rhodium Rh	102.905	.
Chlorine NaCl	35.453	19,400	Palladium Pd	106.4	.
Magnesium Mg	24.312	1,290	Argentum (silver) Ag	107.870	0.00028
Sulfur S	32.064	904	Cadmium Cd	112.4	0.00011
Potassium K	39.102	392	Indium In	114.82	.
Calcium Ca	40.08	411	Stannum (tin) Sn	118.69	0.00081
Bromine Br	79.909	67.3	Antimony Sb	121.75	0.00033
Helium He	4.0026	0.0000072	Tellurium Te	127.6	.
Lithium Li	6.939	0.170	Iodine I	166.904	0.064
Beryllium Be	9.0133	0.0000006	Xenon Xe	131.30	0.000047
Boron B	10.811	4.450	Cesium Cs	132.905	0.0003
Carbon C	12.011	28.0	Barium Ba	137.34	0.021
Nitrogen ion	14.007	15.5	Lanthanum La	138.91	0.0000029
Fluorine F	18.998	13	Cerium Ce	140.12	0.0000012
Neon Ne	20.183	0.00012	Praesodymium Pr	140.907	0.00000064
Aluminium Al	26.982	0.001	Neodymium Nd	144.24	0.0000028
Silicon Si	28.086	2.9	Samarium Sm	150.35	0.00000045
Phosphorus P	30.974	0.088	Europium Eu	151.96	0.0000013
Argon Ar	39.948	0.450	Gadolinium Gd	157.25	0.0000007
Scandium Sc	44.956	<0.000004	Terbium Tb	158.924	0.00000014
Titanium Ti	47.90	0.001	Dysprosium Dy	162.50	0.00000091
Vanadium V	50.942	0.0019	Holmium Ho	164.930	0.00000022
Chromium Cr	51.996	0.0002	Erbium Er	167.26	0.00000087
Manganese Mn	54.938	0.0004	Thulium Tm	168.934	0.00000017
Ferrum (Iron) Fe	55.847	0.0034	Ytterbium Yb	173.04	0.00000082
Cobalt Co	58.933	0.00039	Lutetium Lu	174.97	0.00000015
Nickel Ni	58.71	0.0066	Hafnium Hf	178.49	<0.000008
Copper Cu	63.54	0.0009	Tantalum Ta	180.948	<0.0000025
Zinc Zn	65.37	0.005	Tungsten W	183.85	<0.000001
Gallium Ga	69.72	0.00003	Rhenium Re	186.2	0.0000084
Germanium Ge	72.59	0.00006	Osmium Os	190.2	.
Arsenic As	74.922	0.0026	Iridium Ir	192.2	.
Selenium Se	78.96	0.0009	Platinum Pt	195.09	.
Krypton Kr	83.80	0.00021	Aurum (gold) Au	196.967	0.000011
Rubidium Rb	85.47	0.120	Mercury Hg	200.59	0.00015
Strontium Sr	87.62	8.1	Thallium Tl	204.37	.
Yttrium Y	88.905	0.000013	Lead Pb	207.19	0.00003
Zirconium Zr	91.22	0.000026	Bismuth Bi	208.980	0.00002
Niobium Nb	92.906	0.000015	Thorium Th	232.04	0.0000004
			Uranium U	238.03	0.0033
			Plutonimu Pu	(244)	.

Distribution and abundance of Pleurococcus on trees

AIM

To find out if light intensity affects the distribution and abundance of Pleurococcus on tree trunks.

UNDERLYING ENVIRONMENTAL SCIENCE



The green powdery growth seen on tree trunks is tiny algae known as Pleurococcus. Because they photosynthesise many people think they are plants but they are actually single cell organisms that clump together. When a Pleurococcus cell lands on the tree trunk it releases a slime that sticks the cell to the bark. The Pleurococcus makes an identical copy of itself and each new cell releases more slime. This green mat then spreads across the tree trunk. [1]

Photosynthesis is the conversion of light energy into chemical energy. The equation for this is shown below [2]

Carbon dioxide + water (+ light energy) → glucose + oxygen

Pleurococcus obtains carbon dioxide from the atmosphere and water from rainwater. The green in the cells in the photograph is chlorophyll which collects the light energy. The carbon dioxide and water are converted into glucose and release oxygen into the atmosphere as a by product. The Pleurococcus uses the stored glucose as an energy source [3].

Light energy is a limiting factor for photosynthesis [4]. It is measured as light intensity, which is the rate at which light energy falls on a known area of surface. It changes continually across the day and also across the year so will affect the distribution and abundance of photosynthesisers like Pleurococcus.

DATA COLLECTION

We looked at where Pleurococcus was found (distribution) on six tree trunks and how much was present (frequency) by using a 10cm x 10cm quadrat at 8 compass points around each tree trunk. To compare height distribution Pleurococcus was measured at heights of 0.5m and 1.5 m, and light intensity was measured at the midpoint (1m) using a light meter. A tape measure was used to measure the heights.

Data 1 – Pleurococcus frequency at 0.5m							
Compass point	Tree 1	Tree 2	Tree 3	Tree 4	Tree 5	Tree 6	Average
N	80	32	80	77	59	43	61.8
NE	47	12	75	50	48	13	40.8
E	2	0	50	22	17	0	15.2
SE	0	0	0	10	6	0	2.7
S	0	0	0	5	2	4	1.8
SW	25	30	0	0	16	21	15.3
W	0	95	15	58	43	37	41.3
NW	70	15	95	65	52	39	56.0

Data 2 – Pleurococcus frequency at 1.5m							
Compass point	Tree 1	Tree 2	Tree 3	Tree 4	Tree 5	Tree 6	Average
N	14	22	37	37	6	3	15.7
NE	10	9	12	30	19	12	14.8
E	0	6	0	22	23	15	16.5
SE	0	5	1	10	5	2	4.6
S	0	8	0	5	6	9	7.0
SW	1	16	0	0	1	5	5.8
W	24	5	0	30	12	10	16.2
NW	31	0	10	45	5	1	18.4

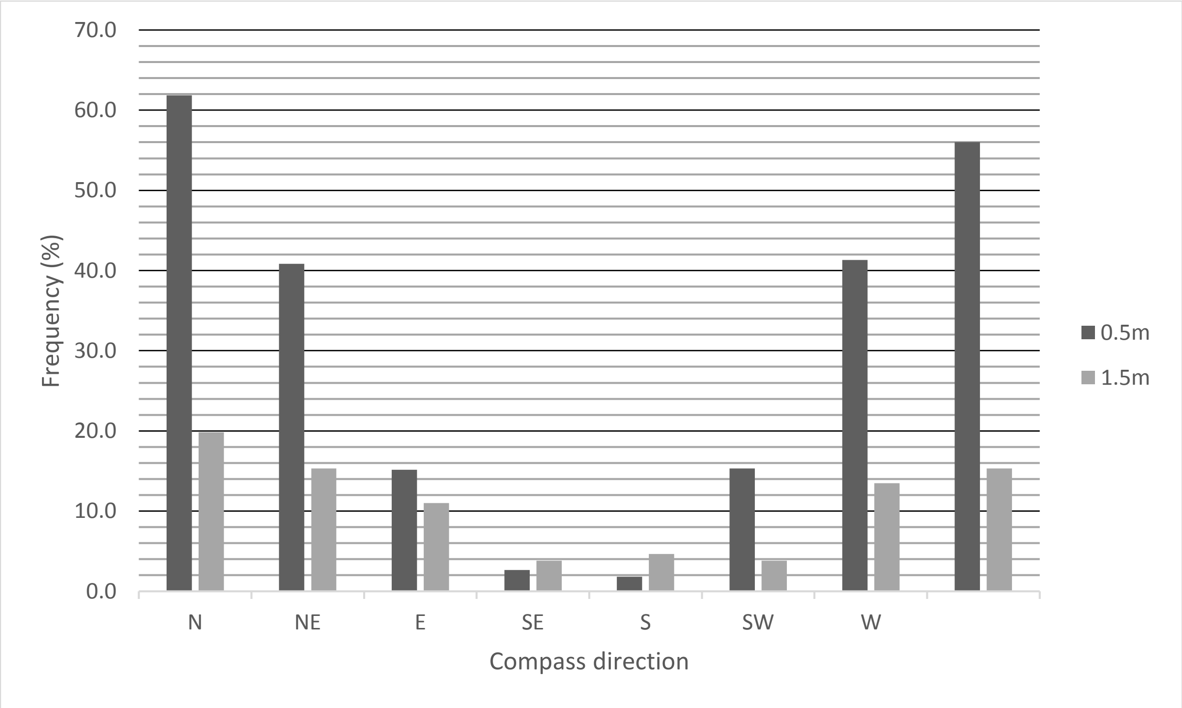
Data 3 – light intensity (lux)							
Compass point	Tree 1	Tree 2	Tree 3	Tree 4	Tree 5	Tree 6	Average
N	4680	2450	4700	2820	5730	2480	3810
NE	4055	1420	5530	1210	5430	1960	3268
E	4640	4700	4460	3600	2500	3100	3833
SE	2100	3540	2240	1950	1770	3780	2563
S	2040	2840	1440	3430	660	2900	2218
SW	3710	2000	2700	2500	1300	2900	2518
W	2010	1880	4320	1700	1600	3530	2507
NW	2020	2460	5430	3590	2500	3700	3283

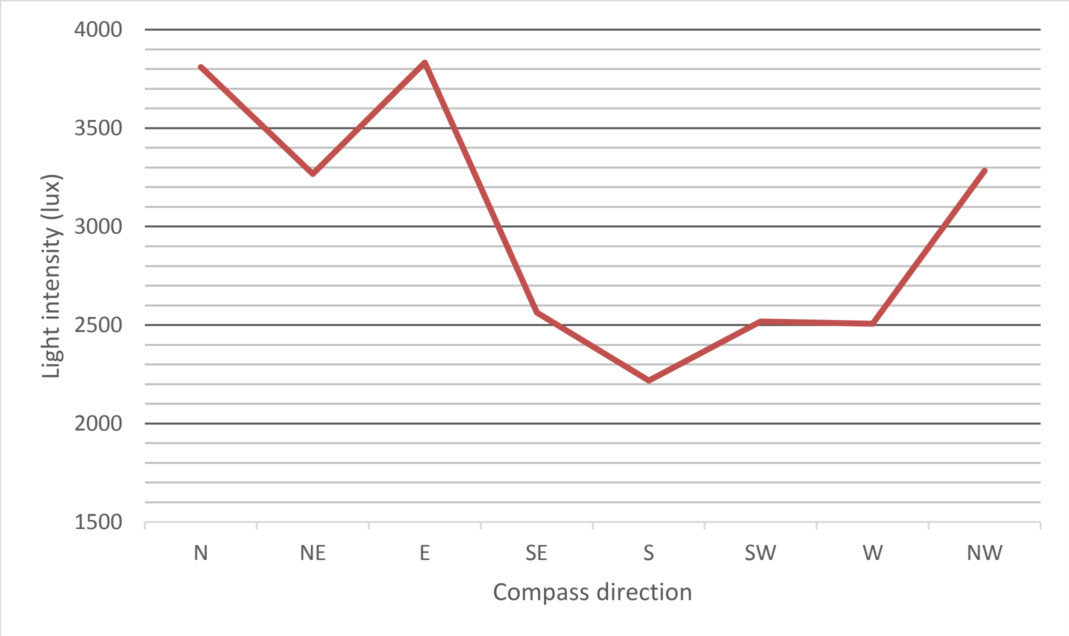
GRAPHS

The average values for the three sets of data have been plotted. I have placed the graphs together so that the Pleurococcus distribution and frequency can be compared with the light intensity.

Graph 1: frequency of Pleurococcus at 0.5m and 1.5m height

Graph 2: light intensity at 1m height





ANALYSIS

The frequency graph shows that more Pleurococcus are found between west-north west-north-north east-east than between east-south east-south-south west-west. This means that Pleurococcus prefer to be in more shaded areas on the tree trunk. This is confirmed by the light intensity graph.

The table shows differences in average Pleurococcus frequency at the two heights. The biggest difference is on the south side of the tree trunks, with 288.9% more Pleurococcus at 1.5m than at 0.5m.

$$\frac{(7.0 - 1.8)}{7.0} \times 100 = 288.9\%$$

Direction	Average Pleurococcus frequency (%)		% change
	0.5m	1.5m	
N	61.8	15.7	-74.6
NE	40.8	14.8	-63.7
E	15.2	16.5	+8.6
SE	2.7	4.6	+70.4
S	1.8	7.0	+288.9
SW	15.3	5.8	-62.1
W	41.3	16.2	-60.8
NW	56.0	18.4	-67.1

CONCLUSION

It can be seen that Pleurococcus likes to grow on the shaded half of trees and mostly nearer the ground. This is because it will be cooler and damper nearer the ground but they still have enough light for photosynthesis. If they grew on the half getting most light the Pleurococcus would dry out because that side gets more sunlight and would be warmer than the shaded side.

EVALUATION

We marked the sampling heights and compass points on all trees before we started measuring so that light intensity readings could be taken quickly. This was good planning as light can change very quickly.

The light intensity data show that values for the east don’t meet the overall trend. This could have been because the sun came out while light intensity on the east side of some of the trees was being measured. The overall trend can be seen from the other compass points.

With eight direction points on each tree, two heights and six trees to measure this was a lot of counting of quadrats. Different people were doing each tree and some might have made mistakes or just guessed. This will have affected reliability of the results.

SOURCES

1 Oxford University (June 2018) https://herbaria.plants.ox.ac.uk/bol/plants400/Profiles/OP/Pleurococcus

2 MadSci Network (June 2018) http://www.madsci.org/posts/archives/1999-10/940127002.Bt.r.html

3 BBC Bitesize (June 2018) http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/plants/plants1.shtml

4 RSC (June 2018) http://rsc.org/learn-chemistry/content/filerepository/cmp/00/001/068/rate%20of%20photosynthesis%20limiting%20factors.pdf