Data Collection
Qualitative Observation

Table 1.0 Observations on before, during and after experiment.

Before experiment	During experiment	After experiment
Agar blocks are dark brown in colour.	Agar blocks slowly start to decolourise after putting in the dilute hydrochloric. The centre of the block is the last to decolourise.	The agar blocks are light yellow.
	The smaller blocks appear to decolourise faster than the bigger blocks.	
	Smallest block decolourise completely first. Biggest block decolourise lasts.	
	Decolouration is slower as it approaches the centre.	

Quantitative Observations

Table 1.1: Surface area, volume, and ratio of surface area to volume of the agar blocks.

Agar block	Surface Area/mm^2	Volume/mm^3	Ratio
1	600.0	1000.0	0.6 : 1.0
2	400.0	500.0	0.8 : 1.0
3	250.0	250.0	1.0 : 1.0
4	150.0	125.0	1.2 : 1.0
5	100.0	62.5	1.6 : 1.0

- To cut out the blocks of agar, a ruler is used. The uncertainty for a ruler is ±0.5mm.

- Agar block 1 is the biggest agar block while 5 is the smallest.

Table 1.2: The time taken for agar blocks to decolourise for Trial 1, Trial 2, Trial 3, Trial 4 and

Trial 5

Agar blocks	Time taken for blocks to decolourise/s (±0.01s)					
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	**Average**
1	3723.00	3634.80	3624.00	2425.20	3655.20	3332.20
2	2889.00	2895.60	3460.80	2357.40	2459.00	2812.36
3	2160.60	2114.4	2487.00	2238.00	2126.80	2225.24
4	1769.40	1866.00	1920.00	1638.00	1683.00	1784.28
5	1444.20	1324.20	1518.00	1590.00	1419.40	1459.12

Table 1.3: The comparison between surface area : volume ratio and time taken for agar blocks to decolourise.

Agar blocks	Surface area : Volume ratio	Averaged time taken for agar blocks to decolourise/s (±0.01s)
1	0.6 : 1.0	3332.20
2	0.8 : 1.0	2812.36
3	1.0 : 1.0	2225.24
4	1.2 : 1.0	1784.28
5	1.6 : 1.0	1459.12

Data Processing

Calculations for surface area of agar blocks:

1. $10mm \times 10mm \times 6 = 600mm^2$

2. $(5mm \times 10mm \times 4) + (10mm \times 10mm \times 2) = 400mm^2$

3. $(5mm \times 10mm \times 4) + (5mm \times 5mm \times 2) = 250mm^2$

4. $5mm \times 5mm \times 6 = 150mm^2$

5. $(2.5mm \times 5mm \times 4) + (5mm \times 5mm) = 100mm^2$

Calculations for volume of each agar blocks:

1. $10mm \times 10mm \times 10mm = 1000mm^3$

2. $5mm \times 10mm \times 10mm = 500mm^3$

3. $5mm \times 5mm \times 10mm = 250mm^3$

4. $5mm \times 5mm \times 5mm = 125mm^3$

5. $2.5mm \times 5mm \times 5mm = 62.5mm^3$

Calculations for surface area to volume ratio:
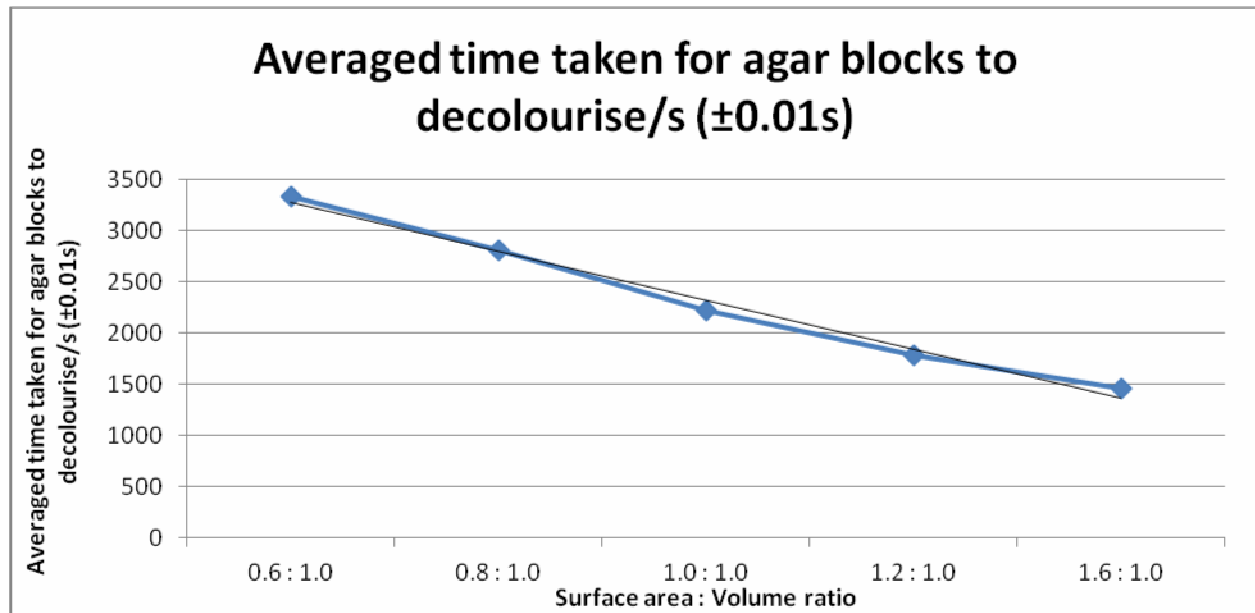
1.   600 : 1000
   =   0.6 : 1.0

2.   400 : 500
   =   0.8 : 1.0

3.   250 : 250
   =   1.0 : 1.0

4.   150 : 125
   =   1.2 : 1.0

5.   100 : 62.5
   =   1.6 : 1.0

Example calculation for time taken for agar blocks to decolourise
- Data obtained from *Table 1.2*, agar block number 1.

$$\left(\frac{3723.00s + 3634.80s + 3624.00s + 2425.20s + 3655.20s}{5} \right) = 3332.20s$$

Graph 1.1: Averaged time taken for agar blocks to decolourise

Conclusion

From the results obtained above, it is agreed that a larger agar block will result in longer time for the agar block to decolourise due to the smaller surface area to volume ratio. A smaller agar block will result in shorter time to decolourise due to the bigger surface area to volume ratio. As seen from *Graph 1.1*, the larger the surface area to volume ratio, the shorter time is needed for agar blocks to decolourise. This can be seen when an agar block with a 0.6 : 1.0 surface area to volume ratio needed 3332.20seconds to decolourise while agar block with 1.6 : 1.0 surface area to volume ratio only needed 1459.12 seconds to decolourise. These observations and results proves that the ratio of surface area : volume is a limiting factor in cell size.

Many important chemical reactions occur within the cell. Substances moves into the cell to be used as fuel for the reactions that occur within cell, collectively known as the cell metabolism. Products of these reactions (waste substances) need to be removed out of the cell in order for metabolism to continue. These two processes (substances moving in and out of cell) depend on the cell's surface area to volume ratio.

This is due to the fact that the metabolic rate of the cell is directly proportional to the cell's volume, hence the chemical activity per unit time. On the other hand, the rate at which substances move in and out of the cell depends on the cell surface area.

The chemical activity of a cell increase as the cell size increase, as more substances needs to be taken in and to be removed. As the cell increase in size, so will the volume and the surface area of the cell, but not to the same extent. As shown above, as cell gets bigger, the surface area to volume ratio gets smaller. This is proven when agar block 1 (the biggest agar block) had the smallest surface area to volume ratio (0.6 : 1.0) while agar block 5 (the smallest agar block) had the biggest surface area to volume ratio (1.6 : 1.0).

If the surface area to volume ratio of a cell gets too small, substances will not be able to enter the cell fast enough to fuel reactions and waste products will start to accumulate within the cell as they are produced more rapidly than they are secreted.

Surface area to volume ratio is also important for heat production and heat loss. If the ratio is too small, the cell may overheat due to faster heat production from the processes of metabolism than they are lost over the cell's surface.

The hypothesis above can be applied to animals (mammals) living in the cold regions of the earth. The Allen's rule theory suggests that, mammals living in cold regions tend to be large in size. Though the cold weather, Antarctic mammals are still able to regulate the same internal body temperature. Their large figure helps them to conserve more energy due to the smaller surface area to volume ratio. This is also true for the opposite: animals that live in warmer climate will have a higher surface area to volume ratio to prevent overheating.

Evaluation

Table 1.4: Problems and effect of problem on the experiment and ways to improve it.

The problem	Effect of problem on	Improvements

	experiment	
It was hard to cut the agar cubes with a ruler as the ruler tend to move and glide.	Will affect the time taken for agar cubes to decolourise	Use different size of square potato or onion cutters. This way, the agar cubes will have a uniform size.
Agar blocks are not 90 degrees angled and are not uniform in size.	May effect the time taken for agar cubes to decolourise. If one agar cube is not the correct size, it will affect the other agar cubes.	Use a 90 degrees angled ruler. Cut a big piece of agar and place it outside the Petri dish. Then cut it into pieces. Usage of different size onion or potato cutter.
The colours of the agar blocks are initially dark brown. It is hard to determine the point at which the decolourisation had stopped. Since different members of the groups predicted the point at which the cubes decolourise, our best judgement will differ from one another.	The time taken for agar cubes to decolourise should be close to each other. However, due to the problem mentioned at the left, time taken for agar cubes to decolourise was different.	Place a white paper behind the test tube so that the brown colour will be more visible. Doing all 5 trials at once. This way, the test tubes with the $HCl_{(aq)}$ and agar cubes can be places side to side on the white sheet. Thus, making it easier to note and record colour change.
The stopwatch was not started directly after the agar cubes were places in the test tubes.	Time of the agar cubes to decolourise will be shorter than it is supposed to.	In order for it to be a fair test, place all the agar cubes in the test tubes and wait for 10 seconds before starting the stopwatch.
Upon placing the agar cubes in the test tubes, some might take longer time than others. This is because, the agar cubes were placed one by one into the test tubes, instead of putting them all at once.	Thus, the agar cube that was places first in the test tube will have a shorter time to decolourise compared to the others as the stopwatch was only started after the last agar cube is placed inside the test tube.	Instead of preparing the $HCl_{(aq)}$ inside the test tube and then adding in the agar cubes, the opposite can be doen, i.e. placing all agar cubes in the test tube before adding $HCl_{(aq)}$. This is because less time will be lost as it is easier to transfer the $HCl_{(aq)}$ into the test tube due to its liquid state.

Bibliography

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