Biology 2019 v1.2

IA2 mid-level annotated sample response

July 2018

Student experiment (20%)

This sample has been compiled by the QCAA to assist and support teachers to match evidence in student responses to the characteristics described in the instrument-specific marking guide (ISMG).

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

2. apply understanding of biodiversity or ecosystem dynamics to modify experimental methodologies and process primary data
3. analyse experimental evidence about biodiversity or ecosystem dynamics
4. interpret experimental evidence about biodiversity or ecosystem dynamics
5. investigate phenomena associated with biodiversity or ecosystem dynamics through an experiment
6. evaluate experimental processes and conclusions about biodiversity or ecosystem dynamics
7. communicate understandings and experimental findings, arguments and conclusions about biodiversity or ecosystem dynamics.

Note: Objective 1 is not assessed in this instrument.

Queensland Government
Queensland Curriculum & Assessment Authority
180956
For all Queensland schools

Instrument-specific marking guide (ISMG)

Criterion: Research and planning

Assessment objectives

2. apply understanding of biodiversity or ecosystem dynamics to modify experimental methodologies and process primary data
5. investigate phenomena associated with biodiversity or ecosystem dynamics through an experiment

The student work has the following characteristics:	Marks
• informed application of understanding of biodiversity or ecosystem dynamics to modify experimental methodologies demonstrated by - a considered rationale for the experiment - justified modifications to the methodology • effective and efficient investigation of phenomena associated with biodiversity or ecosystem dynamics demonstrated by - a specific and relevant research question - a methodology that enables the collection of sufficient, relevant data - considered management of risks and ethical or environmental issues.	5–6
• adequate application of understanding of biodiversity or ecosystem dynamics to modify experimental methodologies demonstrated by - a reasonable rationale for the experiment - feasible modifications to the methodology • effective investigation of phenomena associated with biodiversity or ecosystem dynamics demonstrated by - a relevant research question - a methodology that enables the collection of relevant data - management of risks and ethical or environmental issues.	3–4
• rudimentary application of understanding of biodiversity or ecosystem dynamics to modify experimental methodologies demonstrated by - a vague or irrelevant rationale for the experiment - inappropriate modifications to the methodology • ineffective investigation of phenomena associated with biodiversity or ecosystem dynamics demonstrated by - an inappropriate research question - a methodology that causes the collection of insufficient and irrelevant data - inadequate management of risks and ethical or environmental issues.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Analysis of evidence

Assessment objectives

2. apply understanding of biodiversity or ecosystem dynamics to modify experimental methodologies and process primary data
3. analyse experimental evidence about biodiversity or ecosystem dynamics
5. investigate phenomena associated with biodiversity or ecosystem dynamics through an experiment

The student work has the following characteristics:	Marks
• appropriate application of algorithms, visual and graphical representations of data about biodiversity or ecosystem dynamics demonstrated by correct and relevant processing of data • systematic and effective analysis of experimental evidence about biodiversity or ecosystem dynamics demonstrated by - thorough identification of relevant trends, patterns or relationships - thorough and appropriate identification of the uncertainty and limitations of evidence • effective and efficient investigation of phenomena associated with biodiversity or ecosystem dynamics demonstrated by the collection of sufficient and relevant raw data.	5–6
• adequate application of algorithms, visual and graphical representations of data about biodiversity or ecosystem dynamics demonstrated by basic processing of data • effective analysis of experimental evidence about biodiversity or ecosystem dynamics demonstrated by - identification of obvious trends, patterns or relationships - basic identification of uncertainty and limitations of evidence • effective investigation of phenomena associated with biodiversity or ecosystem dynamics demonstrated by the collection of relevant raw data.	3–4
• rudimentary application of algorithms, visual and graphical representations of data about biodiversity or ecosystem dynamics demonstrated by incorrect or irrelevant processing of data • ineffective analysis of experimental evidence about biodiversity or ecosystem dynamics demonstrated by - identification of incorrect or irrelevant trends, patterns or relationships - incorrect or insufficient identification of uncertainty and limitations of evidence • ineffective investigation of phenomena associated with biodiversity or ecosystem dynamics demonstrated by the collection of insufficient and irrelevant raw data.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Interpretation and evaluation

Assessment objectives

4. interpret experimental evidence about biodiversity or ecosystem dynamics
6. evaluate experimental processes and conclusions about biodiversity or ecosystem dynamics

The student work has the following characteristics:	Marks
• insightful interpretation of experimental evidence about biodiversity or ecosystem dynamics demonstrated by justified conclusion/s linked to the research question • critical evaluation of experimental processes about biodiversity or ecosystem dynamics demonstrated by - justified discussion of the reliability and validity of the experimental process - suggested improvements and extensions to the experiment that are logically derived from the analysis of evidence.	5–6
• adequate interpretation of experimental evidence about biodiversity or ecosystem dynamics demonstrated by reasonable conclusion/s relevant to the research question • basic evaluation of experimental processes about biodiversity or ecosystem dynamics demonstrated by - reasonable description of the reliability and validity of the experimental process - suggested improvements and extensions to the experiment that are related to the analysis of evidence.	3–4
• invalid interpretation of experimental evidence about biodiversity or ecosystem dynamics demonstrated by inappropriate or irrelevant conclusion/s • superficial evaluation of experimental processes about biodiversity or ecosystem dynamics demonstrated by - cursory or simplistic statements about the reliability and validity of the experimental process - ineffective or irrelevant suggestions.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Communication

Assessment objective

7. communicate understandings and experimental findings, arguments and conclusions about biodiversity or ecosystem dynamics

The student work has the following characteristics:	Marks
• effective communication of understandings and experimental findings, arguments and conclusions about biodiversity or ecosystem dynamics demonstrated by - fluent and concise use of scientific language and representations - appropriate use of genre conventions - acknowledgment of sources of information through appropriate use of referencing conventions.	2
• adequate communication of understandings and experimental findings, arguments and conclusions about biodiversity or ecosystem dynamics demonstrated by - competent use of scientific language and representations - use of basic genre conventions - use of basic referencing conventions.	1
• does not satisfy any of the descriptors above.	0

Task

Context
You have completed the following practicals in class: • Determine species diversity of a group of organisms based on a given index (mandatory practical). • Use the process of stratified sampling to collect and analyse primary biotic and abiotic field data to classify an ecosystem (mandatory practical). • Select and appraise an ecological surveying technique to analyse species diversity between two spatially variant ecosystems of the same classification (e.g. a disturbed and undisturbed dry sclerophyll forest) (mandatory practical). • Measure the wet biomass of producer samples. • Measure the population of microorganisms in Petri dishes to observe carrying capacity.
Task
Modify (i.e. refine, extend or redirect) an experiment in order to address your own related hypothesis or question. You may use a practical performed in class, a related simulation or another practical related to Unit 3 (as negotiated with your teacher) as the basis for your methodology and research question.

Sample response

Criterion	Marks allocated	Result
Research and planning Assessment objectives 2, 5	6	4
Analysis of evidence Assessment objectives 2, 3, 5	6	4
Interpretation and evaluation Assessment objectives 4, 6	6	4
Communication Assessment objective 7	2	2
Total	**20**	**14**

The annotations show the match to the instrument-specific marking guide (ISMG) performance-level descriptors.

Key: Research and planning | Analysis of evidence | Interpretation and evaluation | Communication

Note: Colour shadings show the characteristics evident in the response for each criterion.

Communication [2] **acknowledgment of sources of information through appropriate use of referencing conventions** The use of in-text referencing fits the purpose of a scientific report. **Research and planning [3–4]** **a reasonable rationale for the experiment** The rationale shows sound application of scientific concepts to the research question. However, the rationale does not discuss the transfer and transformation of solar energy, or the link between producing biomass and the interaction with carbon cycle components. The use of scientific theory in the response relates to Topic 2: Ecosystem dynamics	**Rationale** Biomass is defined as the amount of living matter per unit area and can be used as a fuel to generate electricity (IUPAC 2006). With increasing concerns about fossil fuels as a finite resource, microalgae are being investigated as a potential source of renewable, biomass fuel. Their ability to rapidly sequester carbon and grow quickly makes them a potential sustainable alternative (Dismukes 2008). Chlorella is a microalgae that has a fast growth rate (relative to other microalgae), is unicellular and lives in freshwater (Mohsen 2017). It is easy to cultivate, has a high chlorophyll content and contains oil that can be made into biodiesel (Chisti 2007). Like most plants microalgae are limited in growth by the presence of sunlight and water. They also require levels of nitrogen, phosphorus and potassium for optimum growth (Wen 2014). Greywater comes from used water in a building that has not come into contact with faeces but cannot be stored for more than 24 hours (Qld Govt 2016). Instead greywater diversion devices can be installed diverting this resource into irrigation. Many laundry detergents and dishwashing powders contain phosphorus. Consequently, this consideration led to question could greywater be used to grow microalgae? This experiment was developed from the original class suggested practical on measuring the wet biomass of producer samples. It aligns to the subject matter in Unit 3 Biodiversity and the interconnectedness of life, Topic 2 Ecosystem dynamics (Functioning ecosystems). Specifically, on explaining the transfer and transformation of solar energy into biomass as

(Functioning ecosystems) of the *Biology 2019* syllabus, but is not used to support the modifications or research question.	it flows through biotic components of an ecosystem. It also aligns to the subject matter on how solar energy produces biomass and interacts with components of the carbon cycle. The modifications to the experiment help show how efficiencies of energy transfer from one trophic level to another, including the productivity (gross and net) of the various trophic levels. The modifications also enabled the experimenter to calculate energy transfer in the form of biomass. This supported learning the subject matter for the course and thus the experiment was beneficial on many levels.
Research and planning [3–4] **a relevant research question** The research question is connected to the rationale and allows the effective investigation of Topic 2: Ecosystem dynamics (Functioning ecosystems). However, the response does not specifically identify the independent variable or the dependent variable.	

Research question

'Does household grey water affect the biomass of *Chlorella* spp.?'

Original experiment

The methodology used has been adapted from:

- SAPS, A-level set practicals – factors affecting the rates of photosynthesis www.saps.org.uk/secondary/teaching-resources/1354-a-level-set-practicals-factors-affecting-rates-of-photosynthesis
- BTI Curriculum Projects in Plant Biology, Algae to Energy, Teacher Manual 2015 btiscience.org/wp-content/uploads/2015/12/b.-Algae-to-Energy-Teacher-Manual-2015.pdf

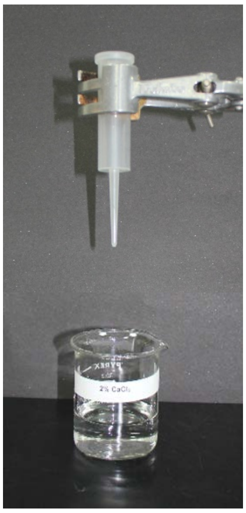


Figure 1: equipment for making the algal balls

(www.saps.org.uk/attachments/article/1354/SAPS%20%20-%20Light%20intensity%20and%20the%20rate%20of%20photosynthesis%20-%20student%20notes.doc)

The original SAPS experiment used algal balls (algae suspended in sodium alginate) with a hydrogen carbonate bioindicator to investigate rates of photosynthesis. The BTI experiment used a photobioreactor. This experiment draws from both experiments and combines the use of algal balls and photobioreactors.

Instructions for making algal balls

1. Place 5cm^3 3% sodium alginate solution into a clean test tube
2. Place 5 cm^3 concentrated algal suspension into a second, clean test tube (the algae should have been on a sunny window sill or under a bench lamp for at least 1 hour before the practical).
3. Swirl the algal suspension and then pour it into the test tube containing the sodium alginate. Stopper the tube and shake to thoroughly mix the algae and the alginate (vigorously enough so that they mix thoroughly but not too vigorously as this may trap air bubbles in the mixture).
4. Place a 12.5cm^3 fine nosed syringe (with the plunger removed) vertically in the clamp stand.
5. Pour approximately 25ml 2% calcium chloride in a 50ml beaker. Place the beaker directly underneath the syringe. Adjust the height of the syringe so that the tip is approximately 10cm above the surface of the

	calcium chloride solution (see figure 1). 6. Pour your algae and alginate mixture into the syringe. The mixture will drip slowly into the beaker of calcium chloride (this will take 5-10mins). 7. When all the mixture has dripped through, leave the algal balls in the beaker of calcium chloride for 5-10 minutes. They will become solid. This amount of mixture, dripped from a height of 12cm, produces about 250 algal balls. 8. Tip the algal balls into a tea strainer and rinse with distilled water. 9. Place the algal balls in a beaker of fresh distilled water until you need them for the investigation (25ml in a 50ml beaker). (From Science & Plants for Schools: www.saps.org.uk)
Research and planning [3–4] **feasible modifications to the methodology** The modifications can be achieved. However, the response does not justify how the modifications will refine, extend or redirect the original experiment. **Research and planning [5–6]** **a methodology that enables the collection of sufficient, relevant data** The methodology shows careful and deliberate thought. It enables collection of adequate data so an informed conclusion to the research question can be drawn. Three repeated measurements for each trial are planned to allow a mean to be calculated. Five variations of the independent variable are planned to allow trends and relationships to be analysed and graphs to be drawn.	**Modifications to the methodology** To ensure that sufficient, relevant data was collected the original experiment was changed to increase the number of samples and measurements. Refinements and extensions were made to the experiment (see below) and all other variables were controlled as per the original experiment. **Refined by:** • using a ten-bottle photobioreactor (with a stone aerator connected to a pump), five bottles containing the control and five containing the treatment solution (see page 16 of Teacher manual). Each photobioreactor will have 10 algal balls. The mass of these will be measured every 24 hours (for the time period) using an electronic balance. • five trials from each sample will be taken to ensure that there is sufficient data to calculate mean and standard deviation. **Extended by:** • investigating greywater as a treatment, based on phosphorus being limiting factors of growth (Lohman 2014) to increase algal biomass (independent variable).

Research and planning [5–6]

considered management of risks and ethical or environmental issues

The response shows careful and deliberate identification and planning to handle risks and ethical or environmental issues in the experiment.

Safety and ethical considerations

- Adhere to safety considerations outlined in the original experiment.
- Review MSDS sheets in Risk Assess for using greywater, dispose of accordingly.
- Wash hands before and after using the photobioreactor to avoid contamination.

Processed data

For the analysis of this experiment the following data processing occurred:

- the mean was chosen as the most appropriate measure of central tendency
- standard deviation was calculated as a measure of central tendency

Analysis of evidence [3–4]

basic processing of data

The response shows the fundamental steps involved in manipulating the raw data mathematically to produce the evidence.

Raw data is manipulated to provide fundamental evidence that responds to the research question. However, standard error and confidence intervals have not been calculated.

Table 1: Sample calculations

Calculation	***Example***
Percentage mass change	*Percentage mass change (Trial 1) = (2g – 0.5g) /0.5g x 100* *Percentage mass change (Trial 1) = 300%*
Mean percentage mass change	$\boldsymbol{\mu}$ (control) = $\frac{441.67+733.33+581.82+733.33+445.45}{5}$ $\boldsymbol{\mu}$ = 573 %
Standard deviation for a sample population	*Standard deviation was calculated in excel by using the STDEV function and the five mean percentage mass changes for each treatment*.

Analysis of evidence [5–6]

collection of sufficient and relevant raw data

The raw data is adequate for forming a conclusion and has direct bearing upon the research question.

Communication [2]

appropriate use of genre conventions

Raw data is recorded with the associated uncertainties and expressed consistently to the correct number of significant figures.

The response uses units and symbols correctly.

Analysis of evidence [3–4]

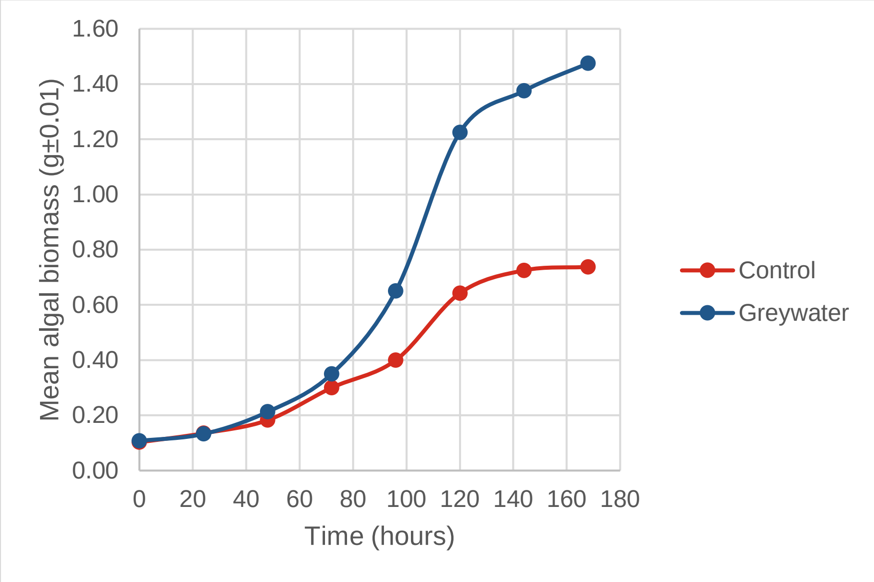
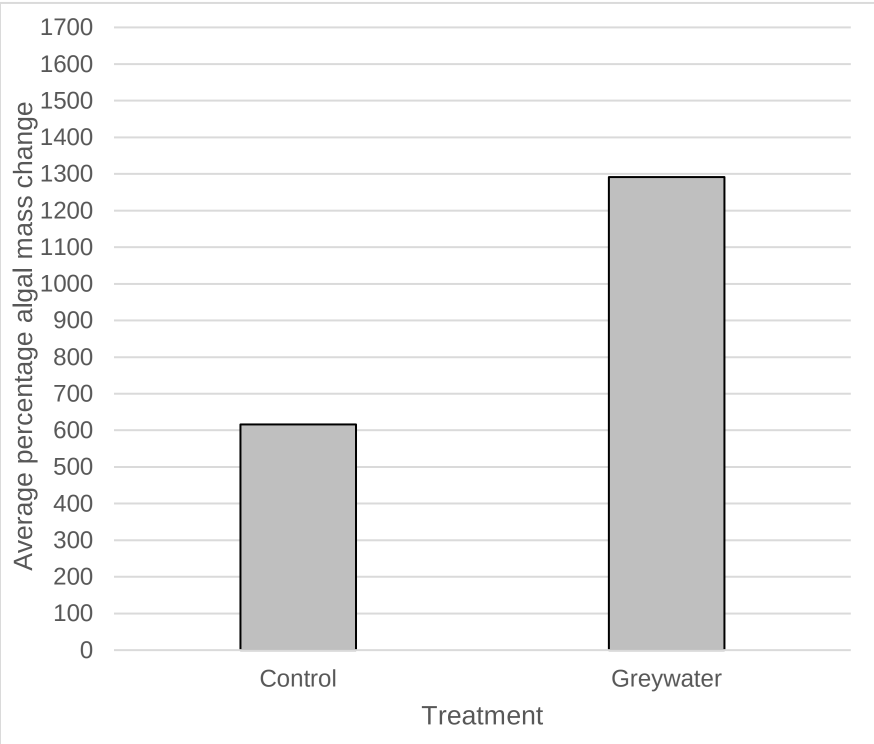
identification of obvious trends, patterns or relationships

The response identifies an easily recognised pattern that has some relevance to the research question.

Table 2: Processed data table for the effect of greywater on the growth of *Chlorella* spp. biomass

Treatment	Photobioreactor no.	*Chlorella* spp. mass (g±0.01)								Percentage change (%)
		0 h	*24 h*	*48 h*	*72 h*	*96 h*	*120 h*	*144 h*	*168 h*	
Control	1	0.12	0.15	0.20	0.25	0.40	0.65	0.65	0.68	466.67
	2	0.09	0.12	0.15	0.35	0.50	0.60	0.75	0.75	733.33
	3	0.11	0.15	0.18	0.40	0.30	0.72	0.75	0.72	554.55
	4	0.09	0.12	0.20	0.20	0.40	0.60	0.75	0.80	788.89
	5	0.11	0.15	0.18	0.31	0.40	0.70	0.70	0.70	536.36
	Mean	**0.10**	**0.14**	**0.18**	**0.30**	**0.40**	**0.64**	**0.73**	**0.74**	**619.51**
	SD	**0.01**	**0.02**	**0.02**	**0.08**	**0.07**	**0.06**	**0.04**	**0.05**	**±137.91**
Greywater	1	0.12	0.15	0.20	0.20	0.80	1.00	1.60	1.60	1233.33
	2	0.09	0.12	0.15	0.60	0.60	0.60	0.50	0.40	344.44
	3	0.11	0.12	0.15	0.50	0.70	1.20	1.20	1.30	1081.82
	4	0.09	0.12	0.25	0.30	0.30	1.50	1.50	1.60	1677.78
	5	0.11	0.14	0.25	0.40	0.80	1.20	1.20	1.40	1172.73
	Mean	**0.11**	**0.13**	**0.21**	**0.35**	**0.65**	**1.23**	**1.38**	**1.48**	**1272.09**
	SD	**0.01**	**0.02**	**0.05**	**0.13**	**0.24**	**0.21**	**0.21**	**0.15**	**±265.00**

Analysis & interpretation: The data shows the mean percentage biomass change of the control treatment was within the range of 445 - 787% whilst the greywater treatment was 1005 - 1575%. The standard deviation has been used as a measure of the uncertainty associated with these averages (±SD). This indicates that the greywater treatment data had a greater uncertainty.

Communication [2] **fluent and concise use of scientific language and representations** The response represents data clearly so that the trends, patterns and relationships can be easily identified. **Analysis of evidence [3–4]** **identification of obvious trends, patterns or relationships** The response identifies an easily recognised pattern that has some relevance to the research question. **Communication [2]** **fluent and concise use of scientific language and representations** The response represents data in an appropriate format to ensure that the trends, patterns and relationships can be accurately interpreted.	 **Figure 2:** Mean algal biomass change over a 168-hour period for control and greywater treatment. **Analysis & interpretation:** The literature suggests that the algal population growth should pass through four stages (lag, exponential, transitional and stationary). This data fits this model for both treatments. The greywater data shows an increased exponential growth phase (48 – 120h) compared to the control treatment. The stationary growth phase (120 – 168h) occurs at a higher final mean biomass in the greywater data. This suggests that the greywater treatment has a positive effect on algal growth.  **Figure 3:** Average percentage Chlorella sp. biomass change (over 168 hours).

Analysis of evidence [3–4]

identification of obvious trends, patterns or relationships

The response identifies an easily recognised pattern that has some relevance to the research question.

Interpretation: The greywater treatment shows an increase in percentage biomass compared to the control sample suggesting this treatment has a positive effect on algal growth.

Evaluation

Limitations of the evidence

Analysis of evidence [3–4]

basic identification of uncertainty and limitations of evidence

The response shows fundamental consideration of the impact of measurement uncertainty. However, measurement uncertainty has not been appropriately propagated through numerical calculations.

The response shows fundamental consideration of the impact of error on the experimental results.

Uncertainty and limitations can be observed from an analysis of the evidence. This can be explained by a lack of reliability and validity in the experimental process.

The masses recorded for the algal biomasses were inconsistent (refer to Table 1, see standard deviation) hence the average percentage change is calculated from data that lacks some reliability. This suggests that not all the variables were fully controlled.

The low sample size of this experiment is a major limitation and consequently, the evidence is limited in its ability to be used to extrapolate the findings of the experiment to the population of *Chlorella* spp.

Interpretation and evaluation [3–4]

reasonable description of the reliability and validity of the experimental process

The response identifies sensible sources of systematic and random error. However, it does not consider the impact of these errors on the reliability and validity of the experimental process.

Sources of error

- The electronic balance used to measure the mass of *Chlorella* spp. is imprecise.
- The samples were not randomly selected and the strain of *Chlorella* spp. was not genetically screened. This contributes to the data being variable and therefore imprecise.
- The composition of the greywater was not determined prior to conducting the experiment. Therefore, it is not known which abiotic and biotic factors are effecting the growth of the *Chlorella* spp.
- The sodium alginate leads to a wet rather than dry biomass reading. Therefore, the algal biomass is determined indirectly.
- The electronic balance does not count algae cells directly. Therefore, this contributes to the data being inaccurate.

Suggested improvements and extensions

Interpretation and evaluation [3–4]

suggested improvements and extensions to the experiment that are related to the analysis of evidence

The suggested modifications address systematic and random errors. However, the response does not use evidence to show that these modifications would improve the reliability and validity of this experiment.

Suggested improvements

This experiment could be improved by increasing the number of repeat readings of each sample, increasing the number of samples and running the experiment (trial) more than once. A random selection technique could be used to improve the bias in the sample. In addition, assessing the composition of the greywater prior to conducting the experiment would improve the methodology.

The data could be made more accurate by using a dry biomass reading. More accurate equipment and more time would improve the evidence overall. The algal balls could also be made by the lab assistant to ensure they were a more consistent shape and size.

Interpretation and evaluation [3–4] **reasonable conclusion/s relevant to the research question** The conclusion is based on sound judgment and stated in terms of the research question, but does not directly refer to evidence.	## Suggested extensions • **Redirect** the experiment by choosing specific chemical treatments found within the composition of the greywater. # Conclusion In conclusion, treatment with household greywater effects the biomass of *Chlorella* spp. It also indicates that *Chlorella* spp. treated with greywater could be used to increase biodiesel outputs. This biodiesel could be used to tackle the sustainability issues faced with dwindling fossil fuel supplies globally. The data could also be used to address growing waste water and greywater concerns in urban environments. As the global population continues to grow exponentially clean water is becoming also becoming a scarce resource. Being able to utilise greywater in this way could hold a key to a more sustainable future.
Communication [2] **fluent and concise use of scientific language and representations** The response is easily understood, avoids unnecessary repetition and meets the required length.	**Word count:** 1627
Communication [2] **acknowledgment of sources of information through appropriate use of referencing conventions** The use of a referencing system fits the purpose of a scientific report.	# Reference List Chisti, Y. 2007. Biodiesel from microalgae. Biotechnology Advances 25:294-306 Dismukes GC, et al. 2008 Aquatic phototrophs: Efficient alternatives to land-based crops for biofuels. Curr Opin Biotechnol.19:235–40. IUPAC, Compendium of Chemical Terminology, 2nd ed. (the 'Gold Book') (1997). Online corrected version: (2006–) 'biomass'. Lohman E. et al 2015. Optimized inorganic carbon regime for enhanced growth and lipid accumulation in Chlorella vulgaris. Biotechnology for biofuels vol 8 biotechnologyforbiofuels.biomedcentral.com/articles/10.1186/s13068-015-0265-4 Mansouri, M. 2016. Predictive modeling of biomass production by Chlorella vulgaris in a draft-tube airlift photobioreactor. Advances in Environmental Technology. 3:119-126 Plant Biology, Algae to Energy, Teacher Manual 2015 btiscience.org/wp-content/uploads/2015/12/b.-Algae-to-Energy-Teacher-Manual-2015.pdf Science & plants for schools 2017. www.saps.org.uk/secondary/teaching-resources/1354-a-level-set-practicals-factors-affecting-rates-of-photosynthesis Queensland government, Department of housing and public works. 2016. 'Greywater' www.hpw.qld.gov.au/construction/BuildingPlumbing/Plumbing/Greywater/Pages/default.aspx Wen, Z. 2014. Algae for biofuel production. www.articles.extension.org/pages/26600/algae-for-biofuel-production