Western Treatment Plant

Cleaning up sewage

VELS Level 6

Strand/Domain	**Dimensions**
Discipline-based Learning/Science	Science knowledge and understanding
	Science at work
Discipline-based Learning/Mathematics	Number
	Measurement, chance and data
	Structure
Discipline-based Learning/The Humanities – Geography	Geographic knowledge and understanding
Physical, Personal and Social Learning/Civics and Citizenship	Community engagement
Interdisciplinary Learning/ICT	ICT for visualising thinking
	ICT for communicating
Interdisciplinary Learning/Communication	Presenting

The pre-activities give students the necessary background to make a visit to the Western Treatment Plant more meaningful. These include an introduction to the terms used in the sewage treatment industry, the processes involved and the necessity to treat sewage before discharge into Port Phillip Bay or Bass Strait.

The post-activities elaborate on aspects of the sewage treatment process observed during the visit. These include experiments to demonstrate the need to reduce nitrogen levels of the effluent, and the effects of changed dissolved oxygen levels in water. The process of osmosis is examined. The feasibility of treating effluent (using reverse osmosis) so that it reaches drinking water standards to supplement Melbourne's domestic water supply, is debated.

State Government Victoria

Melbourne Water is owned by the Victorian Government. We manage Melbourne's water supply catchments, remove and treat most of Melbourne's sewage, and manage rivers and creeks and major drainage systems throughout the Port Phillip and Westernport region. Telephone 131 722 or visit melbournewater.com.au

Melbourne Water

Pre-activity 1: Treating Melbourne's Sewage

Focus

- Introduction to Melbourne's sewerage system and the role of Melbourne Water's Eastern and Western Treatment Plants. Define terms used in the sewage treatment industry, identify items and substances that are introduced to the sewerage system, create a flow chart of sewage treatment processes and calculate average daily volumes of annual sewage flow.

Duration

- Four period sessions

Activity

- Students use the internet to research and define the following terms:
  - sewage
  - sewerage
  - greywater
  - blackwater
  - effluent
  - stormwater.
- Definitions of these terms can be found at www.melbournewater.com.au/content/sewerage/melbournes_sewerage_system/melbournes_sewerage_system.asp and www.melbournewater.com.au/content/drainage_and_stormwater/stormwater/stormwater.asp .
- Individually, students draw a plan of their house (using ICT if available) and label it to show where connections are made to the sewerage system. Ask them to identify the different items and substances that are introduced to the sewerage system. Encourage students to research and note the chemicals that compose the waste (e.g. laundry detergents contain water softeners, surfactants, bleach, enzymes, brighteners, fragrances, and many other agents).
- As a class, combine the lists of substances to make a master list. Classify the items as contributing to greywater or blackwater. Try and classify whether they are organic or inorganic chemicals. The class decides how this information can be displayed in a clear and concise manner and each prepares their list.
- Discuss with the students facts such as that the major component of sewage is water (more than 95%) and that treatment involves the separation of the 5% of other materials from it. Discuss how these materials may affect the environment if they are not removed during the treatment process.

- A list of items that might end up in the sewerage system and their effect is available at http://melbournewater.com.au/content/sewerage/melbournes_sewerage_system/help_keep_our_sewers_clean.asp .
- Students take their lists with them on their visit to the treatment plant and identify where these materials are treated and removed during the purification process.
- Students view the Treatment Plant Explorer (they will need Adobe Flash Player) for the plant they are going to visit.
    - For the Western Treatment Plant visit http://education.melbournewater.com.au/content/sewage_and_recycling/western_treatment_plant/western_treatment_plant_explorer/western_treatment_plant_explorer.asp
- Students collect pictures from the Treatment Plant Explorer that illustrate different stages of sewage treatment and use them to prepare a flow chart that outlines the processes at the plant. Ask them to label their flow chart with descriptions of what happens at each stage of the treatment process using 30 characters or less.

Note: The actual tour students take may vary from the route descriptions provided in the Treatment Plant Explorers.

- Students locate their school in Google Earth. (Google Earth will need to be downloaded from www.google.com/earth/index.html if it is not already available on the students' computers.) Students use the measuring tool to determine the school's dimensions and then calculate its area. If Google Earth is not available, students can physically measure their school ground's dimensions to calculate the area.
- Use the following data for students' calculations. In 2009–10, of a total of about 271,000 megalitres (ML), or 271 gigalitres (GL), of sewage treated by Melbourne Water, the Western Treatment Plant treated 60% and the Eastern Treatment Plant 40%. (Note: 1 megalitre (ML) = one million litres, one gigalitre (GL) = one-thousand million litres.)
- Students determine the annual sewage flow for the treatment plant they are visiting and calculate average daily volume. Using the area of the school ground calculated previously, they determine the depth that that volume of water would be if it was contained within their school grounds, assuming the grounds are level. For example, for a school with an area of five hectares, the average daily throughput of the Western Treatment Plant would equate to a height of about nine metres. Relate this height to physical features in the school or local area, such as sportsgrounds or shopping centres.

Conclusion

- Discuss the need for sewage treatment and the processes involved and ask students to envisage what they might see, smell and hear when they visit the treatment plant.

Pre-activity 2: Sludge gas and biosolids – putting waste to work

Focus

- Investigate how what were traditionally thought of as waste products, can be used to improve efficiency, lower costs and decrease the carbon footprint of sewage treatment. The specific focus is on biogas.

Duration

- Two period sessions

Activity

- For an overview of how Melbourne Water's Eastern and Western Treatment Plants use biogas produced through the treatment process to meet most of the plants' electricity needs, students visit:
    - www.melbournewater.com.au/content/sustainability/renewable_energy/converting_waste_into_energy.asp .
- For the Western Treatment Plant visit:
    - http://lote.melbournewater.com.au/content/sewerage/western_treatment_plant/environmental_improvements/renewable_energy.asp
    - http://lote.melbournewater.com.au/content/sewerage/western_treatment_plant/sewage_treatment_-_how_it_works_today.asp .
- Students work in groups and use the internet to research the following questions:
    - What is biogas?
    - What are anaerobic, aerobic and facultative bacteria and how do they get their energy?
    - How do bacteria contribute to the production of biogas?
    - How can biogas be used?
    - What are the environmental advantages of using biogas?
    - How is biogas made and collected at the plant they are visiting? How does it differ from the process at the other plant?
- Groups prepare a presentation to argue a case for collecting the gas produced during sewage treatment on economic and environmental grounds. Appoint students to the board of directors of a sewage authority and have groups of students make presentations for the board to decide the most compelling case.

Conclusion

- Discuss the need for sustainability and the measures taken by Melbourne Water to reduce their plants' carbon footprints and make them more sustainable.

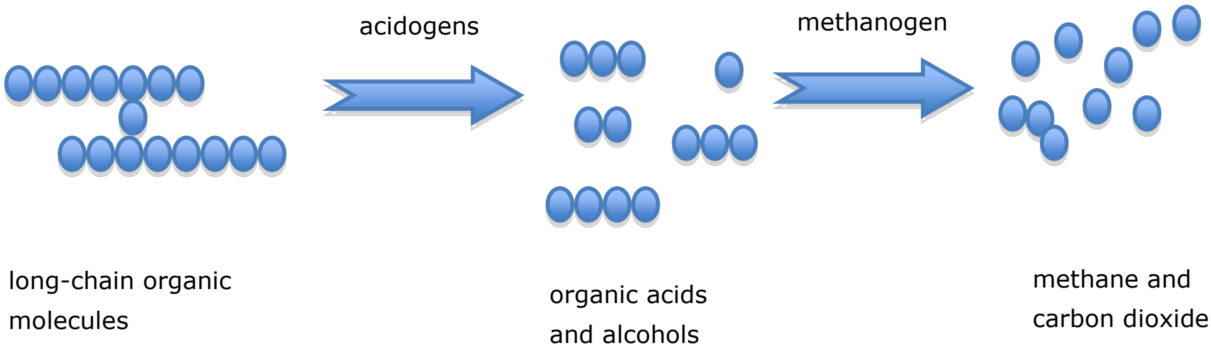
Extension

- In groups, students investigate other sustainability projects undertaken by Melbourne Water such as the recycling of biosolids and water and their possible uses, and then present their findings to the class. Visit: www.melbournewater.com.au/content/sustainability/sustainability.asp

Science background

Anaerobic digestion of solids to produce biogas

- Bacteria types:
    - aerobic – requires oxygen for respiration so live in oxic environments
    - anaerobic – does not require oxygen for respiration, but uses other substances such as nitrates, sulphates and sulphur. Anaerobic bacteria die in the presence of oxygen and thus exist in an anoxic environment.
    - facultative – live in either oxic or anoxic environments and can use either aerobic or anaerobic respiration, depending on their environment.
- Biogas is a mixture principally of methane with carbon dioxide and traces of other gases such as ammonia and hydrogen sulphide. It is produced by anaerobic bacteria as they break down the organic matter in sewage in the absence of oxygen. Oxygen, present in the sewage initially, is removed by aerobic oxygen-loving bacteria and, when this is complete, the anaerobic bacteria can convert complex organic compounds into methane and carbon dioxide.
- Several kinds of anaerobic bacteria feed on the raw sewage, with the by-products of digestion of one type of bacteria providing the food for another bacterial population. The first stage involves liquefaction during which acid-producing bacteria (acidogens) secrete enzymes, which convert long-chain fats, proteins and starches into simpler substances, especially low molecular weight organic acids like acetic acid and alcohols. In the second stage, known as gasification, methane-producing bacteria (methanogens) use enzymes to break down the acids into methane and carbon dioxide.



	Eastern Treatment Plant	**Western Treatment Plant**
Biogas	• Towards the final stage of treatment, methanogenic bacteria produce methane gas which is captured in large tanks. The tanks are kept at 37 °C; no oxygen is present. • Biogas is used to produce electricity to run the plant and heat pipes. • This reduces the amount of dangerous greenhouse gases that are released into the atmosphere, as well as the amount of electricity Melbourne Water needs to import from the grid.	• In the early stage of treatment, methanogenic bacteria in the large lagoon produce methane gas which is captured. Black plastic covers the lagoon which keeps the temperature high and ensures no oxygen is present. • Biogas is used to produce electricity to run the plant. • This reduces the amount of dangerous greenhouse gases that are released into the atmosphere, as well as the amount of electricity Melbourne Water needs to import from the grid.

Reference

- Sustainability, Melbourne Water, www.melbournewater.com.au/content/sustainability/sustainability.asp

Pre-activity 3: Ammonia, nitrates, nitrites and nitrogen cycle

Focus

- Investigate the role of nitrogen in the environment and how it is recycled. Preparation for the visit to the treatment plant and *Post-activity 1: nitrates in the environment*.

Duration

- Two period sessions

Activity

- In small groups, students use the internet to research the nitrogen cycle and its importance for life on Earth. Ask them to also research the sources of nitrogen in sewage. Students use ICT (e.g. Kahootz, PowerPoint, Keynote, Flash, etc) to prepare a simple animation depicting the nitrogen cycle, including the role of sewage.

Conclusion

- Discuss as a class how nitrogen compounds might get into sewage and why it is necessary to control the nitrogen levels in effluent before the effluent is released.

References

- The Nitrogen Cycle, Kids Crossing, http://eo.ucar.edu/kids/green/cycles7.htm
- The Nitrogen Cycle, nitrogen transformations in water, soil and air, NASA Soil Science Education, http://soil.gsfc.nasa.gov/NFTG/nitrocyc.htm
- Nitrogen Cycle, Nick Snowden, www.nicksnowden.net/Module_3_pages/nitrogen_cycle.htm
- The Nitrogen Fate Transformations Game, NASA Soil Science Education, http://soil.gsfc.nasa.gov/NFTG/NFTGame.htm
- Nitrogen removal, Melbourne Water, www.melbournewater.com.au/content/sewerage/western_treatment_plant/environmental_improvements/nitrogen_removal.asp
- Western Treatment Plant, Melbourne Water Sustainability Report, www.mwsustainabilityreport2009.com.au/western-treatment-plant
- Freshening up old technologies: Back to the future, Waste Management & Environment, www.wme.com.au/categories/water/april2_01.php

Pre-activity 4: Water and disease

Focus

- Investigate waterborne diseases that are transmitted through the faecal contamination of drinking water supplies. Select a waterborne disease from the World Health Organization (WHO) list; select and identify countries in which the chosen disease is prevalent and relate this to living conditions. Compare with Australian statistics for the disease and the way waste is treated.

Duration

- Two period sessions

Activity

- Discuss with the class the organisms responsible for waterborne diseases (parasites, protozoa, viruses, amoeba and bacteria).

- Divide the class into groups and set each group the task of identifying a waterborne disease caused by one of these organisms from the list on the WHO site at www.who.int/water_sanitation_health/diseases/diseasefact/en/index.html. Groups research its symptoms, distribution, and interventions that can be used to control it.

- Groups then use WHO data to identify a country where their particular disease is prevalent and the living conditions that lead to outbreaks. They then compare their own living standards and the way water is treated in Australia.

- Groups also investigate the WHO World Health Statistics 2010 data tables to compare cases of selected waterborne diseases and possible connections between these and improved drinking water sources and improved sanitation. Visit www.who.int/whosis/whostat/2010/en/index.html

- Download the data tables. Students examine 'Table 3: Selected infectious diseases' to find countries with the highest reported cases for the waterborne diseases, cholera, malaria and Japanese encephalitis, and note the figures for each.

- They then look at 'Table 5: Risk factors' for the same countries they examined in Table 3, 'Population using improved drinking-water sources', and 'Population using improved sanitation' to see if there is any correlation.

- Students compare these figures with those for Australia or other countries with low reported cases, and draw conclusions.

- Groups make a brief presentation to the class on their findings on waterborne diseases and how the sewage treatment process reduces the risk of their spread.

Extension

- View 'Melbourne's Sewerage System – a Brief History': www.melbournewater.com.au/content/sewerage/melbournes_sewerage_system/melbournes_sewerage_system_-_a_brief_history.asp. Discuss what life in Melbourne might be like today, if the sewage treatment facilities had not been built.

Science background

- An excellent reference for waterborne diseases is the Technical Learning College's development course material, available at www.tlch2o.com/Assignments.htm, under 'Waterborne Diseases' (PDF 11.13 MB). It gives details of the waterborne diseases and the organisms that cause them, as well as common methods of transmission and prevention.

Post-activity 1: Nitrates in the environment

Focus

- Design and conduct an experiment to observe the effect of different chemicals on the growth of plants and then relate the findings to the need to reduce the nitrogen content of effluent before its release into Port Phillip Bay and Bass Strait.

Duration

- One period session for design and set up of experiment. (Allow about one to two weeks for plants to grow and students to make measurements.) One period session for analysis of results.

Activity

- Students work in teams to design an experiment that investigates the effect that different nitrogen compounds have on the growth of wheat, alfalfa, watercress or other fast-growing seeds. They need to consider necessary controls and how they will determine the rate of growth before commencing the experiment. Further details of the activity can be found in *Student worksheet: nitrogen and plant growth*.
- Some equipment students may need includes
    - petri dishes or saucers,
    - thermometers,
    - hygrometers, growing lamps,
    - time-lapse cameras (use a webcam and Gawker for Mac or Webcam Timershot for PC)
    - data loggers.
- Further information on time-lapse photography is available at http://content.photojojo.com/tutorials/ultimate-guide-to-time-lapse-photography
- Revisit the research on the nitrogen cycle from Pre-activity 3. Discuss the fact that plants need nitrogen to synthesise proteins, and nucleic acids to grow and be healthy. However, if nitrogen levels get too high in waterways this can promote rapid plant growth. This rapid growth can in turn result in reduced dissolved oxygen levels because, as the plants die, the aerobic bacteria that decompose them use up the oxygen in the water. Reduced oxygen levels can cause the death of other aquatic life that requires oxygen.
- Ask students to design an experiment to demonstrate how different nitrogen compounds affect plant growth. Students use Student worksheet: nitrogen and plant growth. Students are to consider factors that may affect the dissolved oxygen levels in the samples and how they will be controlled in their experiment.
- Allow about one to two weeks for plant growth.

Conclusion

- When students have drawn conclusions from their observations and related them to the need to control nitrogen levels in the effluent released from the Western Treatment Plant into the sea, discuss how high nitrogen concentration could have a detrimental effect on the marine environment.

Note: This task could be used for assessment purposes to assess student understanding of the selection of appropriate equipment and measurement procedures that will ensure a high degree of reliability in data collected and enable valid conclusions to be drawn.

Post-activity 2: Biological oxygen demand

Focus

- Dissolved oxygen is an indicator of the health of aquatic ecosystems. Biological oxygen demand is a measure for determining the amount of dissolved oxygen needed by aerobic biological organisms to break down the organic material present. It is widely used as an indicator of the degree of organic pollutants in water and, as such, gives a measure of the effectiveness of the sewage treatment process.
- Conduct an experiment to observe the effects of altered dissolved oxygen levels on the organisms present in pond water. Consider the implications of this in sewage treatment.

Duration

- Two period sessions with at least 24 hours between them

Activity

- Students undertake the experiment as outlined in the Student worksheet: dissolved oxygen and aquatic ecosystems to determine the effect of oxygen levels on aquatic organisms, then analyse their observations and relate them to the use of the measurement of oxygen levels as a viable indicator of water quality. They present their results in a suitable format.
- Some equipment students may need includes fresh water sample from a local stream or pond, beakers, jars, USB or stereo microscope, graduated cylinder, dissolved oxygen meter, petri dishes, pipettes, fish-tank pump, tubing and air stones.

Conclusion

- Discuss how the method used by students is used to determine the biological oxygen demand of the water at various stages in the treatment process and as a measure of the purity of the effluent released from the treatment plants.

Note: This task could be used for assessment purposes to assess student understanding of the selection of appropriate equipment and measurement procedures that will ensure a high degree of reliability in data collected and enable valid conclusions to be drawn.

Post-activity 3: From the sewer to the glass

Focus

- The Western Treatment Plant treats some sewage to Class A standards, making it suitable for the irrigation of human food crops and cattle production, but not suitable for use as drinking water. By the end of 2012, the Eastern Treatment Plant will also treat sewage to Class A standards (Currently, some of the Class C water produced at the Eastern Treatment Plant is treated to Class A standards by an external company.) To take this further and make water suitable for direct human consumption, further treatment is necessary. Investigate the processes necessary to treat water to a standard sufficient for human consumption, experiment to demonstrate osmosis, and debate whether Melbourne should use suitably treated effluent to augment its domestic water supply.

Duration

- Two period sessions

Activity

- Purifying effluent: Students view the video of Singapore's NEWater system at www.water.siemens.com/en/videos/water-recycle-reuse/Pages/kranji-water-reuse.aspx (approximately seven minutes duration) to identify the steps used to purify their treated sewage effluent for human consumption. Students then use the information gained to produce a flow chart describing the process.
- What is osmosis?: Students conduct an experiment using potatoes to demonstrate osmosis. They extend this knowledge to explain the process of reverse osmosis and how it can be used to remove mineral and biological contaminants from treated effluent. Further information is available in Student worksheet: potato osmosis.
- Debate: Students form teams to research and debate the question: Should Victoria use recycled water to augment Melbourne's domestic water supply?

References

- Western Treatment Plant Explorer, Melbourne Water Education, http://education.melbournewater.com.au/content/sewage_and_recycling/western_treatment_plant/western_treatment_plant_explorer_-_recycled_water/western_treatment_plant_explorer_-_recycled_water.asp
- Upgrading the Eastern Treatment Plant, Melbourne Water, www.melbournewater.com.au/content/current_projects/sewerage/eastern_treatment_plant_-_planned_upgrade/Eastern_Treatment_Plant_-_planned_upgrade.asp

Student worksheet: Nitrogen and plant growth (post-activity 1)

Introduction

Plants need nitrogen to synthesise proteins and nucleic acids to grow and be healthy. Nitrogen is found naturally in the atmosphere and in the soil, but even though there is an abundance of nitrogen available, the most common form of nitrogen (N_2) cannot be used by plants. Nitrogen can be combined chemically with oxygen or hydrogen to form nitrogen compounds that plants can use. These nitrogen compounds can be added to the soil in the form of ammonium (NH_4^+) and nitrate (NO_3^-) fertilisers.

If nitrogen levels get too high in waterways this can promote rapid plant growth, which can result in the reduction of dissolved oxygen levels, because as the plants die, the aerobic bacteria that decompose them use up the oxygen in the water. Reduced oxygen levels can cause the death of other aquatic life that requires oxygen.

In this activity you are to design an experiment to demonstrate how different nitrogen compounds affect plant growth.

Hypothesis

- What do you think you are going to find out?

Controls

- Consider factors that may affect the dissolved oxygen levels in the samples and how they will be controlled in your experiment. Record them in a table like the one below.

Control factor	**Effect**	**Method of control**
Amount of light	Amount of light will affect rate of growth	Keep all plants under the same lighting conditions

Materials and equipment

- quick-growing seeds (e.g. wheat, alfalfa, water cress, radish)
- solutions of nitrate and ammonium compounds of different concentrations
- list any other materials or equipment you may need (refer to outline for Post-activity 1).

Procedure

- Describe what you will do, considering the necessary controls, and how you will measure the growth of the plants.

Observations and results

- Use tables and graphs to record and display your observations.

Conclusions

- What has this experiment shown about the role of nitrogen in plant growth?
- Why is it necessary to limit the number of nitrogen compounds in effluent before it is released into Port Phillip Bay or Bass Strait?
- How are nitrogen levels in the effluent reduced during the sewage treatment process?

Student worksheet: dissolved oxygen and aquatic ecosystems experiment (post-activity 2)

Introduction

In this activity you will conduct an experiment to observe the effects of altered dissolved oxygen (DO) levels on the organisms present in pond water. You will then consider the implications of this in sewage treatment. Oxygen enters the water as rooted aquatic plants and algae undergo photosynthesis, or by direct transfer across the air–water interface. The amount of oxygen that can be held by the water, the dissolved oxygen, ranges between 0–18 ppm (parts per million) under normal conditions and depends on the water temperature, salinity and pressure.
DO is an important indicator of a healthy aquatic ecosystem as oxygen is essential for respiration by aquatic animals. To support a diverse population, natural systems generally require DO levels of at least 5–6 ppm. If organic matter such as animal waste or improperly treated sewage is introduced to the system, algae growth can increase. As the algae die off and are decomposed, oxygen is consumed by aerobic bacterial action which can cause DO levels to fall below those needed to support some aquatic species, upsetting the balance in the ecosystem.

Hypothesis

- How do you think the DO levels of the samples will change over the 24-hour period and how will this affect biodiversity?

Controls

- Consider factors that may affect the DO levels in the samples and how they will be controlled in your experiment. Record them in a table like the one below.

Control factor	**Effect**	**Method of control**
Temperature	Increased temperature will decrease the solubility of oxygen in water	Measure the DO at the same temperatures

Materials

- fresh water sample from a local stream or pond
- 1,000 mL beaker or large container
- 3 x 500 mL beakers or jars to set up miniature water ecosystems
- USB or stereo microscope

- 500 mL graduated cylinder
- dissolved oxygen meter
- petri dishes
- pipettes
- fish-tank pump, tubing and air stones set up to provide air to 2 beakers
- regulator or paper clip to reduce the air flow to beaker 2.

Procedure

- Take an approximate 1,000 mL sample of the water from a local stream or pond.
- Pour a portion of the sample into a petri dish and examine it under the microscope.
- Capture photographs, draw or describe in detail the types and numbers of living organisms you observe.
- Use the DO meter to measure the DO level of the water sample.
- Measure three equal samples of the water into three beakers or jars and label as follows:
    - beaker 1 – Control. No aeration
    - beaker 2 – Slight aeration
    - beaker 3 – Increased aeration.
- Place the beakers in an area where they will not be disturbed for 24 hours.
- Connect beakers 2 and 3 to the fish-tank pump.
- Reduce the flow of air into beaker 2 using the regulator or paper clip so it is about half that going into beaker 3
- Leave the beakers undisturbed for 24 hours, ensuring that the pump keeps running.
- After 24 hours, place a sample from each beaker into a petri dish and view them under the microscope. Photograph, draw or describe in detail the types and numbers of living organisms you observe.
- Use the meter to measure the DO level in each beaker and record your results.

Results and observations

- Devise a suitable table to record your observations and measurements.

Conclusions

- Does the data collected support your hypothesis? Why or why not?

- Write a short paragraph explaining how each water sample changed based on the DO levels.
- What can you conclude about the DO levels and biodiversity?
- What implications do your findings have regarding the discharge of effluent from sewage treatment plants?
- How does the treatment process at the plant you visited control the DO level of its effluent water?

Student worksheet: Potato osmosis (post-activity 3)

Introduction

Osmosis occurs when water molecules are allowed to pass through a semi-permeable membrane that stops solutes from passing through. Osmosis will happen when the concentration of the solutions is different on each side of the semi-permeable membrane and so water moves from the side of lower concentration to that of higher concentration, tending to dilute it, until equilibrium is reached. Reverse osmosis occurs when pressure is applied to the more concentrated solution forcing the water backwards through the membrane.

Hypothesis

- What changes do you think you may see over the period of observation?

Controls

- Consider factors that may affect the dissolved oxygen (DO) levels in the samples and how they will be controlled in your experiment. Record them in a table like the one below.

Control factor	**Effect**	**Method of control**
Temperature	Increased temperature will increase the rate of evaporation of water	Keep both potatoes at the same temperature

Materials

- 1 large potato
- 100 mL saturated sodium chloride solution
- distilled water
- 2 petri dishes
- sharp knife

Procedure

- Use the knife to cut the potato in half and cut about 1 cm from the bottom of each half so they have a flat base to stand on.
- Carefully scoop out a well in the top of each half, being careful not to cut through the bottom of the potato.
- Stand each half in a petri dish and label the dishes:
    - dish 1 – high concentration

  - dish 2 – low concentration.

- Pour saturated sodium chloride solution into dish 1 until about 5 mm deep. Two-thirds fill the well in the potato with distilled water. Mark the levels in the petri dish and on the potato.
- Pour distilled water into dish 2 until about 5 mm deep. Two-thirds fill the well in the potato with the saturated sodium chloride solution. Mark the levels in the petri dish and on the potato.
- Over a number of days, let the dishes stand, undisturbed and away from direct sunlight, and observe what happens to the liquid levels in the potato and the dish and any other changes.

Results and observations

- Devise a suitable table to record your observations and record what you see over a number of days.
- What did you notice about the movement of water in dish 1?
- What did you notice about the movement of water in dish 2?
- What has been the trend in the movement of the water?
- What would you expect to happen if the pressure on the salt solution was increased?
- What would you expect to happen if the pressure on the distilled water was increased?

Conclusions

- Write a simple statement describing the movement of water and salt, and what could be causing it.
- Explain the process of reverse osmosis and how it can be used to treat effluent to drinking water standards.

Curriculum mapping

Strand/ Domain	**Dimensions**	**Level**	**Standard**
Discipline-based Learning/Science	Science knowledge and understanding	6	Identify and classify the sources of wastes generated, and describe their management, within the community and in industry. Use examples to explain the sustainable management of resources. Explain how the action of micro-organisms can be both beneficial and detrimental to society.
	Science at work	6	Use the relevant science concepts and relationships as one dimension of debating contentious and/or ethically based science-related issues. Formulate their own hypotheses and plan and conduct investigations in order to prove or disprove them. Use chemicals (including biomaterials), equipment, electronic components and instruments responsibly and safely. Select appropriate equipment and measurement procedures that will ensure a high degree of reliability in data collected and enable valid conclusions to be drawn. Present experimental results using appropriate data

			presentation formats.
Discipline-based Learning/Mathematics	Number	6	Carry out computations to a required accuracy in terms of decimal places and/or significant figures.
	Measurement, Chance, Data	6	Estimate and measure length, area, surface area, mass, volume, capacity and angle. Select and use appropriate units, converting between units as required. Decide on acceptable or tolerable levels of error in a given situation. Interpret and use mensuration formulas for calculating the perimeter, surface area and volume of familiar two- and three-dimensional shapes and simple composites of these shapes. Convert between units of measurement as appropriate.
	Structure	6	Apply the algebraic properties to computation with number to rearrange formulas.
Discipline-based Learning/The Humanities – Geography	Geographic knowledge and understanding	6	Analyse development issues and formulate and evaluate comprehensive policies, including those for sustainable use and management of resources.

Physical, Personal and Social Learning/Civics and Citizenship	Community engagement	6	Draw on a range of resources, to articulate and defend their own opinions about political, social and environmental issues in national contexts. Contest, where appropriate, the opinions of others. Develop an action plan which demonstrates knowledge of a social or environmental issue
Interdisciplinary Learning/ICT	ICT for visualising thinking	6	Are efficient and effective users of appropriate ICT tools and editing techniques for assisting in visualising thinking Discriminate between tools and strategies based on their suitability for problem solving in new situations.
	ICT for communicating	6	Apply techniques to locate more precise information from websites, including searching general and specialised directories, and applying proximity operators
Interdisciplinary Learning/Communication	Presenting	6	Demonstrate understanding of the relationship between form, content and mode, and select suitable resources and technologies to effectively communicate. Use subject-specific language and conventions in accordance with the purpose of their presentation to communicate complex information. Provide constructive feedback to others and use feedback and reflection in order to

			inform their future presentations.

Connections to the Australian Curriculum

Australian Curriculum	**Content strands/ sub-strand**	**Content descriptions**
Geography	Geographical knowledge and understanding	Not available at this time
Mathematics	Measurement and geometry/ Using units of measurement	Year 9 Solve problems involving the surface area and volume of right prisms. (ACMMG218) Year 10 Solve problems involving surface area and volume for a range of prisms, cylinders and composite solids (ACMMG242)
Science	Science Understanding/ Biological Sciences	Year 9 Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)
	Science Understanding/ Earth and space sciences	Year 10 Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189)
	Science as a Human Endeavour/ Nature and development of science	Years 9 and 10 Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158)/ (ACSHE192)

	Science as a Human Endeavour/ Use and influence of science	Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities/(ACSHE161)/ (ACSHE195)
	Science Inquiry Skills/ Questioning and predicting	Years 9 and 10 Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)/ (ACSIS198)
	Science Inquiry Skills/ Planning and conducting	Plan, select and use appropriate investigation methods, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)/ (ACSIS199)
	Science Inquiry Skills/ Processing and analysing data and information	Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS169)/ (ACSIS203)
	Science Inquiry Skills/ Evaluating	Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)/ ACSIS205)
	Science Inquiry Skills/ Communicating	Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)/ ACSIS208)