Creating Science – Plastic and Gak

Plastic: So important, useful, and seemingly omnipresent in our technological society. What can we learn about its make-up, its uses, and the hidden dangers of this powerful product…? ***#CreatingSciencePlastic***

Note: this activity is intended to go over two weeks, and includes ***#CreatingScienceGak***

Suggested Outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science understanding

- Chemical sciences F: Objects are made of materials that have observable properties.
- Chemical sciences 4: Natural and processed materials have a range of physical properties; these properties can influence their use.
- Chemical sciences 6: Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting.

Science inquiry skills

- Planning and conducting 4: With guidance, plan and conduct scientific investigations to find answers to questions, considering the safe use of appropriate materials and equipment (ACSIS065)

Science as a human endeavour

- Use and influence of science 4: Science knowledge helps people to understand the effect of their actions (ACSHE062)

Science vocabulary words

Tier 1 (Everyday words)

- Reduce, Reuse, Recycle

Tier 2 (Dual meaning)

- Plastic – technically means 'able to change form without breaking', but is usually used to refer to the glossy, slippery materials we use a lot in our society. Even though some plastics aren't very plastic (i.e., reshapable), they are still called plastic.

Tier 3 (Specialised vocabulary)

- Plasticity is the general property of all materials that are able to deform without breaking.
- The names of various plastics, such as Gak, Casein, PET, and millions of others.

Warning

- Some chemicals used in this activity, such as PVA glue or borax, can be mildly toxic if ingested or used to excess without proper cleaning. Please exercise all caution.
- Borax is actually about as safe as vinegar: fine in small doses, not good for eyes, and wash hands after use. Do not use repeatedly or go to bed without washing hands!
- When making Casein, it requires milk almost at the point of boiling. Please exercise all appropriate caution.
    - Also, while still hot the Casein can be remoulded. This is an ideal time for student to burn themselves trying to make it look 'cool'. Please have a plan in place for manipulating scalding hot casein (gloves or tools), and a plan in place for students who still manage to burn their fingers.
- The plastics we make today are deliberately non-recyclable. This encourages students to place these plastics in the rubbish bin where they can be dealt with properly.

Preparation

For Gak, you will need:

- PVA (poly vinyl acetate) glue. Some craft stores sell transparent PVA glue which makes a clear, slime-like gak.
- Borax (can be bought at the supermarket cleaning isle). This product is about as safe as vinegar to use in schools, however, remember to wash hands carefully after use.
- Plastic zip-lock bags.
- Art smocks, and gloves if you'd like to be super careful.
- Possibly food colouring, if you're brave – the colouring gets everywhere and on everything.

For Casein, you will need:

- One cup of milk
- 4 teaspoons of white vinegar
- A bowl to mix the milk and vinegar in
- A strainer to collect the casein in
- A means of heating the milk up to almost boiling
- Gloves to handle hot milk and casein
- If desired – a mould to press the casein into.

Learning Intent (student friendly)

'We are learning to' (WALT) – take better care of the plastics in our world.

Success criteria

'What I'm looking for' (WILF) – safe creation of a plastic, and responsible handling and disposal of it.

Student learning goals

Help students make a self-monitored learning goal for this lesson, such as 'make plastic' or 'learn how to recycle and reuse plastic properly'.

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations?

- Students will make casein or gak.
- Students will display safe handling and disposal procedures.
- Students will research another kind of plastic, such as polystyrene or PET (Polyethylene terephthalate), and discuss how it is made, used, and recycled or disposed of safely.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students questions can and should guide student learning, more material is presented for you convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

This activity is well suited to this age group, but will require constant supervision and careful adult support. Children at this age can have difficulty with focus. Avoid tangents if you're attempting to make a key point. Make Casein as a demonstration only, after practice.

Middle:

Expand student understanding with a deeper investigation of the plastics around the home and school. Help students to collect plastic rubbish from the classroom and playground, and deal with it properly. Make casein with careful adult supervision.

Teen:

Challenge advanced students to find the history and development of a certain plastic. What makes us so sure the chemical model we use is effective and accurate?

Students at this age should be able to handle more exact measurements for Casein, and may be challenged to extend their learning with some further experimentation.

Engage

Give students some plastic objects to explore.

- Ask them to consider what they are made of, i.e., what they look like at the particle level.

Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

Explore

Make some Gak (see activity) explaining that the PVA glue is like a large number (billions) of long chains (with carbon atoms for a backbone – hundreds and sometimes thousands of links long!)

Ask: What do you think happens when the borax mixes with the PVA?

- What do you think we should call this 'easily reshaping' property? [The technical term is 'plastic'.]

MAKE SURE you explain to the children the end-of-life plan for our new plastic. [Bin it.]

Explain

Explain: Plastics are usually long chain molecules, like spaghetti. When you add borax to PVA glue, it shrivels up the long chains, allowing them to tangle into each other without being locked into place like a solid is, turning the liquid into a semi-solid that can easily be reshaped.

Plastics

Plastics are a wonderful addition to modern society, but they do have their problems!

A few points:

- Plasticity is the general property of all materials that are able to irreversibly deform (i.e., permanently change shape) without breaking,
- Plastic surgery does not typically use artificial plastic, but refers to the more generic use of the term 'plastic' in the reshaping of human flesh.
- By the same token, some plastics aren't 'plastic' – i.e., they will break before successfully deforming.
- The world's first fully synthetic plastic was bakelite, invented in New York in 1907 by Leo Baekeland[4] who coined the term 'plastics'.[5]

Discuss: What can be done about plastic waste in your country (for example, see resources below.)

Elaborate

Can you find some plastics around the house, and name them? How are they made, where do they come from, and how long does it take for them to degrade?

Casein - Another way to make a simple plastic:

Casein, a fun and quite permanent plastic. From http://sciencebob.com/make-plastic-milk/

You will need

- One cup of milk
- 4 teaspoons of white vinegar
- A bowl to mix the milk and vinegar in
- A strainer to collect the casein in
- A means of heating the milk up to almost boiling
- Gloves to handle hot milk and casein
- If desired – a mould to press the casein into.

What to do

Ask your friendly adult to heat up the milk until it is hot, but not boiling.
Now ask the adult to carefully pour the milk into the bowl.
Add the vinegar to the milk and stir it up with a spoon for about a minute.
Now the fun part, pour the milk through the strainer into the sink – careful it may be hot!
Left behind in the strainer is a mass of lumpy blobs.
When it is cool enough, you can rinse the blobs off in water while you press them together.
Now just mould it into a shape and it will harden in a few days. – Cool!

How does it work?

Plastic? In milk? Well, sort of. You made a substance called CASEIN. It's from the latin word meaning "cheese." Casein occurs when the protein in the milk meets the acid in the vinegar. The casein in milk does not mix with the acid and so it forms blobs. True plastics, called polymers, are a little different. Have fun!

MAKE IT AN EXPERIMENT

The project above is a DEMONSTRATION. To make it a true experiment, you can try to answer these questions:

1. Will more vinegar make more casein?
2. Will you get the same results with low-fat milk, soy milk?
3. Do all types of vinegar work?
4. Will other acids, such as lemon juice and orange juice work?

What does this teach us?

Once set, casein cannot be reshaped with heat – it is known as a **thermosetting plastic**. Other plastics, such as those used in most drink bottles, can be reshaped with heat. They are called **thermoplastic plastics**.

Activity - You can see this for yourself if you press a hot object, such as a needle or soldering iron, onto a plastic drink bottle in order to reshape or sculpt it. There's only one problem – IT CREATES TOXIC GASSES! Many plastics can be reformed with heat – but the kind of conditions we need (including massive amounts of air pressure) are not easily created in the classroom.

Evaluate

- Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?
- Review their technique for making plastics
    - What worked, what didn't?
    - Did they follow instructions accurately?
    - Do they have a plan for disposing of their plastic?

Success criteria

- Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- Did you achieve your learning goal?
- What did you learn?
- What worked to help you achieve it?
- What might you do better next time?
- (If needed) where can you go for extra help or information?

Assessment

Prior learning:

Take time to focus on planned content material during the engage phase, for example, ask students what they think plastics are made out of, who came up with the ideas, and what the eventual fate of various plastics will be.

Formative:

Have students explain their theory of the molecular model of plastics and compare their ideas with official descriptions.

Summative:

Encourage students to present a research report on their favourite plastic, including its:

- History and development.
- Chemical formula.
- Disposal and recycling.

Help students produce a poster to be put up at the local shopping centre encouraging the recycling of plastic bags. You might find them being very supportive of this idea!

So what?

- Materials can be changed:
    - Sometimes those changes are physical – ie, reshaping plastic.
    - Sometimes they are chemical – ie, making plastics.
- All materials we make have an effect on society.
    - What are they useful for?
    - What is their eventual fate – how are they disposed of/recycled?

Creating science

Science understanding

As we explored plastics, we learnt that:

- Chemical sciences F: Objects are made of materials that have observable properties.
- Chemical sciences 4: Natural and processed materials have a range of physical properties; these properties can influence their use.
- Chemical sciences 6: Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting.

Science inquiry skills

As we carefully made some of our own plastics (Gak and/or Casein) we:

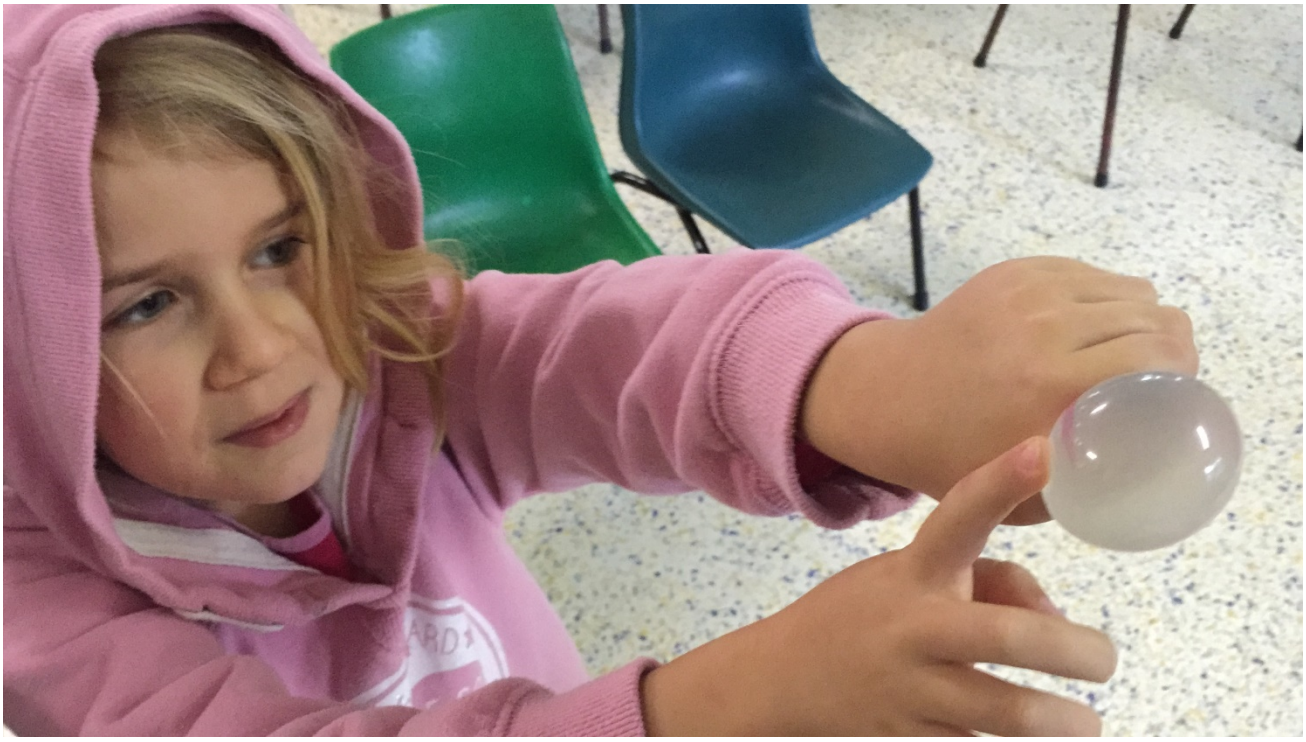
- Planning and conducting 4: With guidance, plan and conduct scientific investigations to find answers to questions, considering the safe use of appropriate materials and equipment (ACSIS065)

Science as a human endeavour

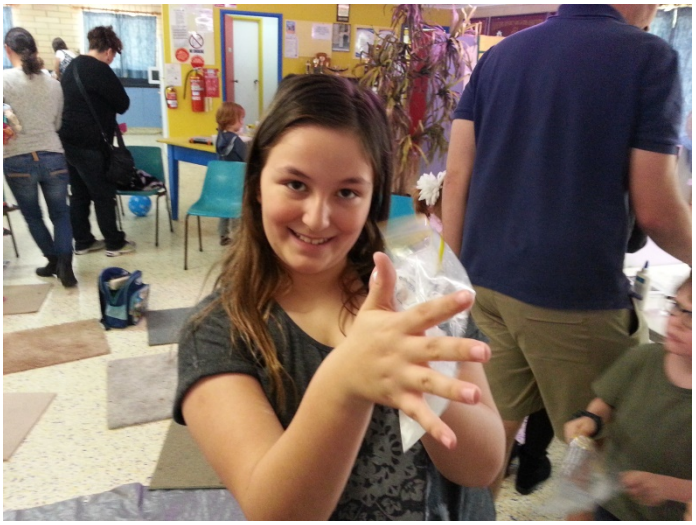
As we learnt about, and put into practice, ways to limit plastic use and misuse in society, we learnt that:

- Use and influence of science 4: Science knowledge helps people to understand the effect of their actions (ACSHE062)

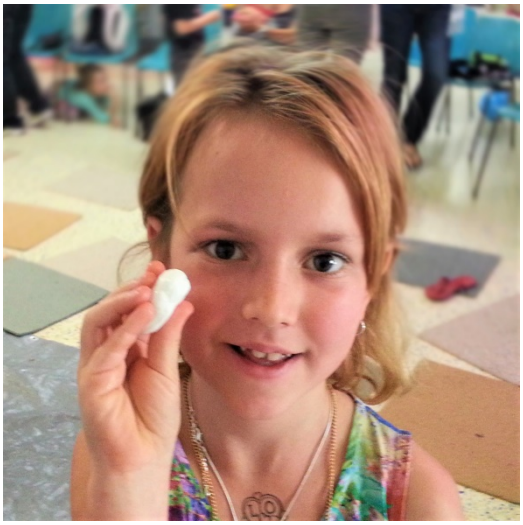
Tips from the Masters



"Plastic" means it can change its shape without breaking.



Squish the borax and PVA up good and well!



Rinse, and keep it dry once it's made!!!

Appendix - Some basic plastics (there are literally millions!)

- Polyester (PES) – Fibers, textiles.
- Polyethylene terephthalate (PET) – Carbonated drinks bottles, peanut butter jars, plastic film, microwavable packaging.
- Polyethylene (PE) – Wide range of inexpensive uses including supermarket bags, plastic bottles.
- High-density polyethylene (HDPE) – Detergent bottles, milk jugs, and molded plastic cases.
- Polyvinyl chloride (PVC) – Plumbing pipes and guttering, shower curtains, window frames, flooring. IT WAS DISCOVERED BY ACCIDENT IN 1872 BY EUGINE BORMAN.
- Polyvinylidene chloride (PVDC) (Saran) – Food packaging.
- Low-density polyethylene (LDPE) – Outdoor furniture, siding, floor tiles, shower curtains, clamshell packaging.
- Polypropylene (PP) – Bottle caps, drinking straws, yogurt containers, appliances, car fenders (bumpers), plastic pressure pipe systems.
- Polystyrene (PS) – Packaging foam/"peanuts", food containers, plastic tableware, disposable cups, plates, cutlery, CD and cassette boxes.
- High impact polystyrene (HIPS) -: Refrigerator liners, food packaging, vending cups.
- Polyamides (PA) (Nylons) – Fibers, toothbrush bristles, tubing, fishing line, low strength machine parts: under-the-hood car engine parts or gun frames.
- Acrylonitrile butadiene styrene (ABS) – Electronic equipment cases (e.g., computer monitors, printers, keyboards), drainage pipe.
- Polyethylene/Acrylonitrile Butadiene Styrene (PE/ABS) – A slippery blend of PE and ABS used in low-duty dry bearings.
- Polycarbonate (PC) – Compact discs, eyeglasses, riot shields, security windows, traffic lights, lenses.
- Polycarbonate/Acrylonitrile Butadiene Styrene (PC/ABS) – A blend of PC and ABS that creates a stronger plastic. Used in car interior and exterior parts, and mobile phone bodies.
- Polyurethanes (PU) – Cushioning foams, thermal insulation foams, surface coatings, printing rollers (Currently 6th or 7th most commonly used plastic material, for instance the most commonly used plastic in cars).

Appendix – some resources for plastic use

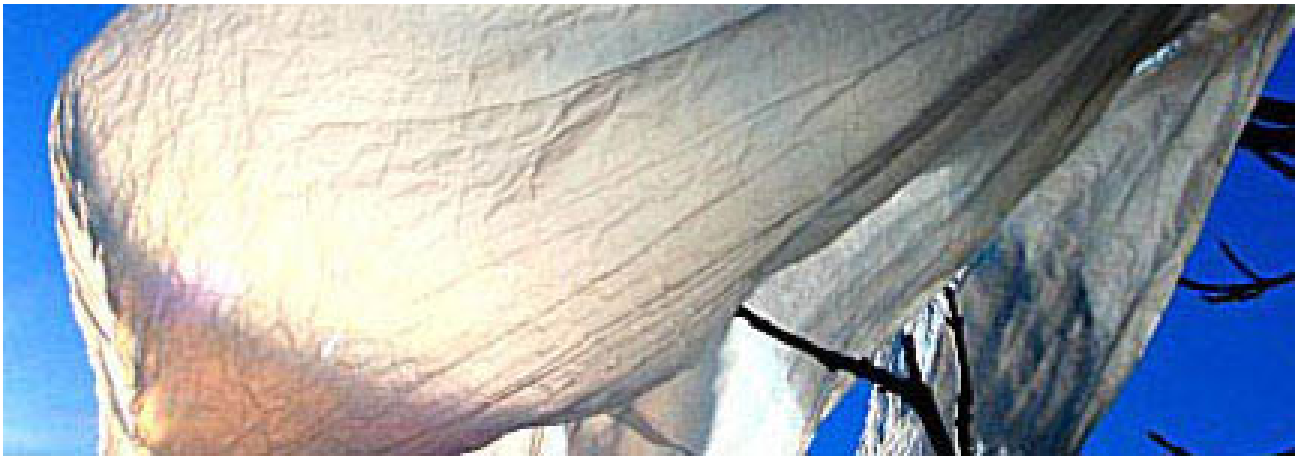
Making plastic 'plastic' - https://www.questacon.edu.au/outreach/programs/science-circus/activities/fantastic-shrinking-plastic

Clean up Australia day information, taken 12th may 2015 from http://www.cleanup.org.au/au/Campaigns/plastic-bag-facts.html (see overleaf) This totally brilliant information gives you a great way to MAKE A DAILY DIFFERENCE in our beautiful country.

With contributions taken 6 June 2015 from http://www.futurenergia.org/ww/en/pub/futurenergia/chats/bio_plastics.htm

Clean up Australia day

Plastic as a Resource



Plastics are made from non-renewable natural resources such as crude oil, gas and coal. According to the 2002 Nolan ITU Report for Environment Australia on Plastic Shopping Bags - Analysis of Levies and Environmental Impacts; just 8.7 plastic checkout bags contain enough embodied petroleum energy to drive a car 1 kilometre.

Plastic bags are recyclable. If plastic is not recycled, this embodied energy is lost from the resource chain.

Downloadable Materials

Say NO To Plastic Bags Fact Sheet (91.08kb)

Plastic Bag Report - Actions to Reduce Usage Around the World (2012.8kb)

Use of Plastic Bags in Australia

Plastic bags have been around for 30 years now. It is estimated worldwide that 1 trillion bags are used and discarded every year.

Australians use 3.92 billion plastic bags a year, that's over 10 million new bags being used every day. An estimated 3.76 billion bags or 20,700 tonnes of plastic are disposed of in landfill sites throughout Australia every year. Australians dump 7,150 recyclable plastic bags into landfills every minute or 429,000 bags every hour.

It is estimated that around 50 million bags enter the Australian litter stream every year. Unless they are collected, they remain in the environment and accumulate at a staggering rate. If these 50 million plastic bags were made into a single plastic sheet, it would be big enough to cover the Melbourne CBD.

Production of Waste in Australia

Australians are the second highest producers of waste, per person, in the world with each of us sending over 690 kilograms of waste to landfill each year (the United States is the highest waste producer). The amount of waste placed in landfill each year in Australia is enough to cover the state of Victoria.

Plastic Waste and Clean Up Australia Day

Plastic has remained the most common category of rubbish picked up on Clean Up Australia day over the last 20 years. In 2009, it made up 29% of all rubbish found. Of the plastic rubbish found, 17.6% were plastic bags with an average of 40 plastic bags being found at each Clean Up site.

That means there is an average of half a million shopping bags collected every year on Clean Up Australia day.

What Can I recycle?

There are 2 types of plastic bags:

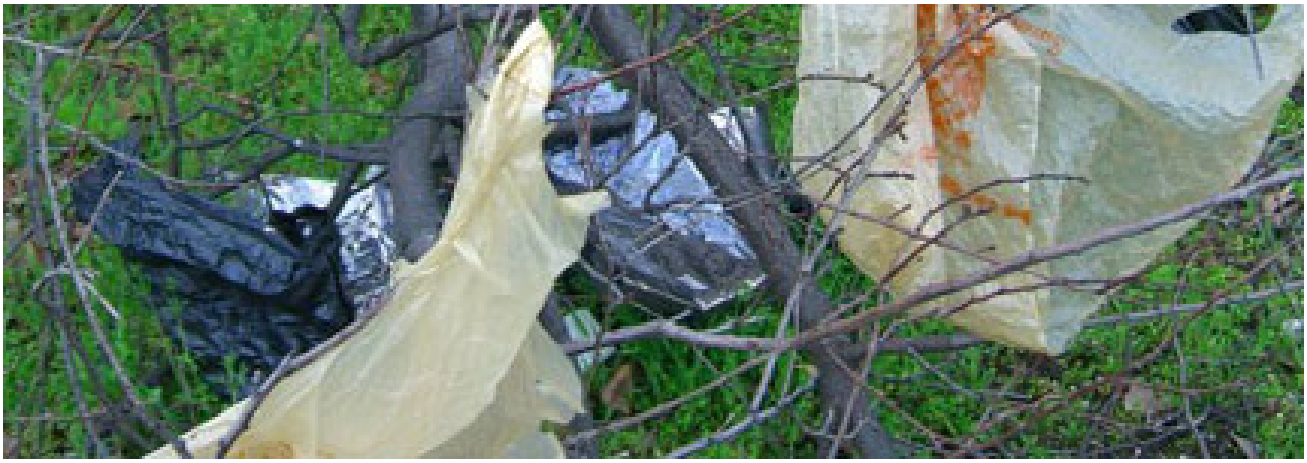
1. High Density Polyethylene (HDPE) bags - They are the thin singlet bags used by over 80% of retailers, including supermarkets. These can be recycled at most supermarkets. Generally they are not collected through your local kerbside recycling, however one or two local councils are currently trialling their collection - contact your local council first to see if they collect plastic bags.

2. Low Density Polyethylene (LDPE) bags - These are the thicker bags used by less than 20% of retailers, usually for luxury goods. While they can be recycled there are few collection points. Check with your local council to see if they collect LDPE plastics.

How does plastic litter harm the environment?

Many thousands of marine mammals and seabirds die every year around the world as a result of plastic litter. When the animal dies and decays the plastic is free again to repeat the deadly cycle. There are 2 major reasons that plastic bags are particularly problematic in the litter stream:
1. They last from 20 - 1 000 years
2. They escape and float easily in air and water, travelling long distances

Litter Outcomes



Because plastic bags last so long, every year, the number of plastic bags in the litter stream increases. Currently, only 3% per cent of plastic bags used in Australia are recycled.

References

(1) Worldwide Home Environmentalists Network home.vicnet.net.au/~when/plastic.htm (2) Environment Australia, Plastic Shopping Bags - Analysis of Levies and Environmental Impacts (Nolan ITU, 2002) www.deh.gov.au/industry/waste/plastic-bags/bags-analysis.html