Environmental sustainability of adult incontinence AHPs in Australia

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If you are interested in learning more about this project, or future research initiatives, contact one of the authors using the addresses provided below.

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Absorbent Hygiene Products (AHPs) are essential healthcare and hygiene products, used daily by billions of people worldwide. AHPs include infant nappies, menstrual products, and products designed to manage urinary and faecal incontinence (Subhankar Maity et al., 2023). These products play a critical role in maintaining health, dignity, independence, and participation in education, employment, and social life (Bartels & Manchester, 2011). As a result, 30 million tonnes of AHPs end up in the world's landfills or incinerators annually, according to data from the nappy and absorbent hygienic product industries (European Commission, 2017). For individuals living with incontinence, AHPs are often indispensable, enabling daily activities that would otherwise be difficult or impossible. As populations age and demand for continence care increases, ensuring that these products can be provided sustainably is becoming an increasingly important challenge (Hristova, 2025).

Compared with infant nappies and menstrual products, adult incontinence products occupy a unique position within the AHP sector. While infant nappies are typically used for a relatively predictable period of approximately two to three years (O'Brien et al., 2009), incontinence may affect individuals across the lifespan and often requires long-term management (Continence Foundation of Australia, 2021). Product requirements vary considerably depending on an individual's age, sex, mobility, and symptom severity, resulting in a wide diversity of product types, absorbencies, and designs. Adult incontinence can often be managed or treated (Johns Hopkins Medicine, 2026; Vaughan et al., 2011), meaning that product demand is dependent on healthcare access and treatment uptake.

The prevalence of incontinence is substantial and is expected to grow as populations age. In Australia, 1 in 3 people experience some degree of urinary or faecal incontinence, with the majority of those affected being under the age of 65 (Continence Health Australia, 2026). Despite its prevalence, incontinence remains highly stigmatised, contributing to low rates of people seeking healthcare and treatment intervention (Garcia et al., 2005). This stigma extends beyond healthcare and into research, where adult incontinence products have received considerably less environmental assessment than infant nappies.

Existing life-cycle assessments of infant products have identified substantial environmental impacts associated with raw material extraction, manufacturing, transport, and disposal (Environment Agency, 2005; Iskandar Shah et al., 2025; Kakonke et al., 2019) However, adult incontinence products differ substantially in their design, composition, patterns of use, and duration of consumption. There have been limited studies assessing the sustainability of adult incontinence products (Bou Kheir et al., 2025; Gu et al., 2023; Willskytt & Tillman, 2019) and only one investigating the Australian context (Thompson Brewster et al., 2022). As a result, many questions remain regarding the environmental impacts of adult continence care and the most effective strategies for reducing them.

The Australian context presents additional challenges. Most of the raw materials used in AHP production are manufactured overseas, while almost all used incontinence products are disposed of through landfill. Consequently, the environmental burden associated with these products is distributed across international supply chains and domestic waste systems. Understanding where the greatest environmental impacts occur, and which interventions are most likely to reduce them, is essential for developing effective regulatory responses.

In a 2023 paper, (Vaittinen et al., 2023), the need for each society around the world to define sustainability in the context of continence and to work with the existing systems to transition to a more sustainable alternative was emphasised.

This review addresses four questions:

1. What environmental challenges associated with adult incontinence AHPs require the most urgent attention?

1. How might environmental objectives interact with user health, dignity, and quality of life?
1. What opportunities exist for alternative materials, manufacturing processes, and disposal systems?
1. Which knowledge gaps should be prioritised for future research?

The aim of the review is to provide a foundation for future research, policy development, and industry innovation in sustainable continence care.

Previous research on infant products

The fundamental material composition of AHPs has remained largely unchanged, as can be seen in Figure 1. Research conducted on infant nappies provides a useful starting point for understanding the environmental impacts associated with adult continence care.

Absorbent hygiene products contain a core of superabsorbent polymer (SAP) and fluff pulp, designed to retain bodily fluids away from the skin (Jassal & Textile Institute, 2011). Superabsorbent polymers are capable of absorbing large quantities of liquid (Denagbe et al., 2025). Additional components commonly include polyethylene film, nonwoven polypropylene, adhesives, and elastic materials (Arquillos et al., 2007).

The most common superabsorbent polymer (SAP) used in absorbent hygiene products (AHPs) is sodium polyacrylate, while polypropylene nonwoven materials is commonly used as a top sheet (Holdway & Dowling, 2023). As seen in Figure 1, infant nappies were estimated to consist of approximately 36–38% fluff wood pulp, 30–45% sodium polyacrylate SAP, 16–23% polypropylene nonwovens, and around 6% polyethylene (Cordella et al., 2015; Mendoza et al., 2019). However, more recent analysis of products available in the United Kingdom reported a somewhat different composition, comprising approximately 26% fluff pulp, 39% SAP, 22% polypropylene, and 3% polyethylene (Holdway & Dowling, 2023). Polyethylene is used in the backsheet to prevent leakage. Polypropylene nonwovens form the top sheet and other surface-contact layers, providing comfort while allowing liquid to pass rapidly into the absorbent core.

SAPs are of particular concern due to the energy-intensive nature of their production, their persistence in the environment, and their potential contribution to microplastic pollution (Arumugam et al., 2024). The most used SAP, sodium polyacrylate (Gosden et al., 2023), is typically manufactured through gel polymerisation and derived from fossil-fuel feedstocks. Although bio-based alternatives derived from starch or cellulose have been developed, these materials currently remain more expensive and less commercially available than conventional SAPs (Arunraj et al., 2024). The ecological footprint of bio-based SAPs can be greater than synthetic-based options. With further research and development, bio-based could potentially offer a more environmentally neutral material (V. S. et al., 2025).

As demonstrated in Figure 2, life-cycle assessments of infant absorbent hygiene products consistently identify raw material extraction and manufacturing as the stages responsible for the largest share of environmental impacts. Substantial energy inputs and abiotic resource consumption are required to produce fluff pulp, superabsorbent polymers, plastics, and other product components. While disposal receives considerable public attention, evidence suggests that most of the environmental damage occurs before products are ever used.

Fluff pulp contributes disproportionately to overall environmental impacts, as seen in figure 3. The environmental burden associated with fluff pulp arises from forestry operations, energy use during processing, transportation requirements, and end-of-life management.

The environmental impacts of absorbent hygiene products extend beyond ecological concerns with large potential impacts on human health. Life-cycle assessment studies indicate that emissions generated during the production and disposal of infant products contribute to ozone formation, carcinogenic toxicity, and non-carcinogenic toxicity, as seen in Table 1.

These metrics represent substantial potential impacts. The health-based limit for DCB in drinking water is 0.04 mg (0.00004g) (Australian Drinking Water Guidelines, 2026). Therefore, the estimated carcinogenic toxicity equivalent of 17.38 kg 1,4-dichlorobenzene (1,4-DCB) is sufficient to bring approximately 434.5 million litres of water to Australia's drinking-water threshold value. Similarly, the non-carcinogenic toxicity equivalent would be sufficient to bring approximately 11.7 billion litres of water to the maximum recommended concentration. Additionally, despite being a minor contribution in Australia's overall NOx equivalent emissions (Dunse et al., 2025), the estimated NOx emissions have the potential to impact local air quality at site of production.

In addition to impacts on human health, life-cycle assessment studies suggest that infant absorbent hygiene products contribute to a wide range of environmental pressures, including climate change, air pollution, eutrophication, acidification, and ecotoxicity, as presented in Table 2.

The magnitude of these impacts is dependent on local environmental conditions and ecosystem sensitivity. The global warming potential associated with the nappies used during a child's first 2.5 years of life is approximately equivalent to driving a standard passenger vehicle from Adelaide to Darwin, based on emissions data from the National Transport Commission (2022). Similarly, emissions associated with freshwater and marine eutrophication have the potential to critically affect millions of litres of aquatic ecosystems. Phosphorus at 20 µg/L is sufficient to trigger eutrophication (Yang et al., 2008). The 220 grams phosphorus-equivalent freshwater eutrophication potential is enough to trigger eutrophication of 11 million litres, and the 60 grams of phosphorus equivalent marine eutrophication potential is enough to trigger eutrophication in 3 million litres of seawater. Enough PM2.5 is produced by one infant's nappies to bring 88,000,000 m^3 (0.088 km^3) of air to the safe threshold level recommended by the World Health Organisation (World Health Organisation, 2021).

Considerations for adult products

Adult incontinence products differ from infant products in several important ways, including product design, duration of use, user requirements, and material composition.

Absorbent hygiene products designed for adult incontinence can generally be grouped into pads, disposable underwear (pants), and all-in-one products (Subhankar Maity et al., 2023). Disposable underwear is estimated to account for approximately half of the global market for disposable incontinence products, while disposable pads account for roughly one-quarter (Market Data Forecast, 2024). All-in-one products account for approximately 20% of the market (Subhankar Maity et al., 2023).

Within these broad categories, considerable variation exists in shape, absorbency, fit, fastening systems, and intended use. Pads may be rectangular or winged (Cottenden, 1988). There is a substantial variation in product dimensions and user preferences across different age groups (Cha, 2023). The precise composition of many commercially available products is not publicly disclosed, and detailed information regarding polymer types, additive chemicals, material proportions, and manufacturing processes is often unavailable. This limits the ability of researchers, policymakers, and consumers to compare products based on environmental performance.

Infant nappies are generally used for a relatively predictable period of approximately two to three years and are broadly similar in function across users. In contrast, adult incontinence products are used by individuals with widely varying ages, mobility levels, anatomical requirements, and symptom severity. Adult incontinence may persist throughout adulthood and old age. Consequently, cumulative resource consumption and waste generation can be substantially greater over an individual's lifetime.

Adult products are frequently larger than infant nappies and may therefore require greater quantities of absorbent materials, plastics, adhesives, and packaging. However, adult continence care also includes a broader range of product types, including pads and liners that may contain significantly fewer materials than traditional all-in-one products.

Findings from one study comparing different AHP product types suggested that with consistent product materials and components, the environmental impact can be accurately estimated based on product weight and size. (Muthu et al., 2013)

As seen in Table 3, the effect of increasing the proportion of bio-based or biodegradable materials is highly dependent on the environmental assessment framework used.

By focusing on product selection and correct product sizing, meaningful reductions in environmental burden could be made (Willskytt & Tillman, 2019).

Similarly, a 2013 life-cycle assessment of a bio-based disposable nappy concluded that environmental benefits were most strongly influenced by the choice of biopolymer, local sourcing of materials, and the availability of composting infrastructure (Mirabella et al., 2013). However, reducing product size where clinically appropriate, and therefore reducing material requirements for the product, produces larger environmental benefits than increasing the proportion of bio-based materials alone (Willskytt & Tillman, 2019).

Material substitution alone is unlikely to provide a complete solution, and environmental outcomes depend on the broader production and waste-management systems within which products operate.

The Australian impact

While Australians consume large volumes of absorbent hygiene products, the majority of the raw materials required for their manufacture are produced overseas. This means that many of the environmental impacts associated with continence products used in Australia occur beyond Australian borders, while the resulting waste is managed domestically.

Most environmental impacts associated with AHPs occur during the extraction and manufacture of these materials. Understanding where these materials are produced is critical to understanding where environmental impacts occur.

The global production of fluff pulp is highly concentrated geographically, with approximately 92% of production occurring in North and South America (Smithers, 2016). Australia also produces only 0.4% of the world's crude oil (Geoscience Australia, 2025), limiting domestic access to a key feedstock required for the manufacture of plastics and superabsorbent polymers. Furthermore, Australia currently has no domestic manufacturers of superabsorbent polymer or polyethylene (Australian Strategic Policy Institute, 2024) and only one manufacturer of polypropylene (Viva Energy, 2023).

As a result, the environmental impacts associated with producing the core materials used in adult incontinence products largely occur outside Australia. Greenhouse gas emissions, energy consumption, water use, land-use change, and chemical emissions associated with manufacturing are therefore predominantly generated within overseas jurisdictions rather than within Australia itself.

This pattern is also reflected in the Australian continence product market. Independence Australia, one of Australia's largest online retailers of incontinence products, offers more than 400 distinct pads, pants, liners, and all-in-one products sourced from a diverse range of manufacturers (Independence Australia, 2025). The manufacturers listed in Table 4 include both Australian and international companies, reflecting the highly globalised nature of the sector.

Of the manufacturers identified, nine are Australian and eight are international. However, even products assembled or marketed by Australian companies frequently rely on imported raw materials. Consequently, the environmental burden associated with manufacturing remains predominantly international regardless of where final product assembly occurs. Some Australian manufacturers, such as Cottons, Ontex, and NightNDay, have Australian-based production (Night N Day Group, 2025; Ontex, 2025).

This finding has important implications for sustainability policy. Many of the environmental impacts associated with products used in Australia occur outside Australian regulatory systems and are therefore difficult for governments, healthcare providers, and consumers to directly influence. While Australia bears responsibility for consumption, it has comparatively limited control over the environmental performance of the supply chain.

From a global perspective, reducing the environmental footprint of continence products requires improvements in material production, manufacturing efficiency, and supply-chain sustainability. However, these impacts largely occur overseas. In contrast, the environmental impacts associated with disposal occur within Australia and directly affect Australian ecosystems, communities, and waste-management infrastructure. Disposal represents the most practical point of intervention available to Australian policymakers.

Several environmental issues are particularly relevant to Australia. Greenhouse gas emissions generated through landfill methane production contribute to national climate-change targets and emissions inventories. Leachate generated from landfill sites poses risks to groundwater resources, particularly in regions dependent on local aquifers. Long-term accumulation of plastics and synthetic polymers within landfill systems also presents an unresolved intergenerational waste-management challenge, as many product components are likely to persist for centuries.

Australia's relatively low population density and extensive land availability mean that landfill capacity is currently less constrained than in many European and Asian countries. The environmental impact of waste disposed of in landfill is completely dependent on the regualtion and uptake of the landfill itself.

The sustainability challenge associated with adult incontinence products in Australia is a disconnect between where environmental impacts occur and where policy intervention is most feasible. Manufacturing contributes most of the environmental burden but occurs largely overseas, while disposal contributes a smaller proportion of total impact but occurs within Australian jurisdictions where governments and industry possess greater capacity to act.

Considerations for Disposal

Although life-cycle assessment studies consistently identify manufacturing as the dominant contributor to the environmental impact of absorbent hygiene products, disposal remains an important consideration.

Bio-based materials such as fluff pulp are often perceived as environmentally superior to plastic components; however, under the anaerobic conditions typical of landfill environments, these materials decompose slowly and anaerobically, producing methane (Environment Victoria; 2017 Ximenes et al., 2008).

Methane is a potent greenhouse gas and a significant contributor to climate change. Organic waste currently disposed of in Australian landfills is estimated to account for approximately 2.5% of

Australia's total greenhouse gas emissions, equivalent to roughly 13 million tonnes of carbon dioxide annually (Department of Climate Change, Energy, the Environment and Water, 2022).

The plastic components of AHPs presents a different challenge. Polyethylene, polypropylene, and synthetic superabsorbent polymers may persist within landfill systems for between 150 and 500 years depending on local conditions, however in a well-managed landfill this is unlikely to impact the surrounding ecosystems. Unlike biodegradable materials, these components do not contribute substantially to methane generation but instead create a long-term accumulation of persistent waste.

An additional consideration is the human waste contained within used products. Urine and faeces introduce biological contaminants that distinguish AHP waste from many other consumer products. As biodegradable components break down and precipitation infiltrates landfill cells, there is potential for contaminants to enter leachate streams and ultimately affect groundwater quality. Consequently, the disposal of AHPs raises both environmental and public health considerations.

Nearly all used incontinence AHP waste in Australia is disposed of as municipal solid waste in landfill. The composition of this waste is estimated to be approximately 60% urine and faeces, 20% non-biodegradable materials, and 20% biodegradable materials, as seen in Figure 4 (Thompson Brewster et al., 2022). While organic recycling, material recovery, and mechanical-biological treatment facilities exist within the Australian waste system, including composting and pyrolysis facilities (Blue Environment Pty Ltd, 2022), but AHP waste is not currently included in any of these operations and is instead directed to landfill (Thompson Brewster et al., 2022).

As of 2013, the most recent year for which a national audit was conducted, there were 279 registered landfills across Australia, with 75% of the country's waste sent to 38 large sites, 20% to 78 medium sites, and the remaining 5% distributed across 163 smaller facilities (Pickin, 2013). On average, approximately half of AHP waste ends up in landfills equipped with leachate and biogas collection systems, as illustrated in Figure 5. Since 2013, numerous projects have upgraded landfills across Australia (NSW EPA, 2021). The absence of more recent national data makes it difficult to assess the current state of infrastructure.

The actual impact of landfill disposal is entirely dependent on the management of the landfill itself. As seen in Figure 6, while many landfills manage the production of methane effectively, preventing release into the environment, many landfills remain unsealed. Additionally, leachate, toxic runoff produced when precipitation passes through landfill contents, can contaminate nearby groundwater sources, degrade soil quality, and harm aquatic ecosystems (Gunarathne et al., 2024). While all tap water in Australia undergoes filtration and treatment before consumption, protecting source water from contamination remains essential. The presence of human waste in landfills, particularly those lacking a cell lining, poses an elevated risk of pathogen contamination that treatment processes may not fully mitigate.

In response to the limitations of landfill disposal, a wide range of alternative waste-management pathways for AHPs have been explored internationally. These include composting, anaerobic digestion, pyrolysis, gasification, material recovery and recycling, production of refuse-derived fuel, dark fermentation, co-digestion with sludge or algae, mushroom cultivation, and use as a soil amendment.

Composting represents one of the most mature alternatives to landfill. Since 2002, the City of Toronto's Green Bin program has accepted AHP waste through the municipal organic-waste stream (City of Toronto, 2017). Plastic materials are mechanically removed, while biodegradable components are processed through anaerobic digestion systems that produce both compost and biogas (City of Toronto, 2017). The biogas is upgraded into Renewable Natural Gas and injected into the energy grid, while the compost is marketed for commercial use. Toronto estimates that AHPs account for approximately 6–7% of all material diverted from landfill through the program (Hasham, 2025).

The Nappy Loop pilot (CSIRO, 2022; Paterson, 2023) generated compost and biogas through anaerobic digestion (Li, 2022). Five months after commencement, approximately two tonnes of waste had been processed, and the resulting compost was reported to be free of detectable plastic contamination (ABC, 2022). Toxicity testing also found no elevation of trace elements beyond ecological or human-health thresholds (Kumar et al., 2023). The project did not progress.

In Australia, Relivit proposed a large-scale recycling facility for absorbent hygiene products but never progressed to commercial operation (Australian Ageing Agenda, 2012; Arlington, 2013). Project Divert, conducted by Essity in regional Victoria between 2018 and 2023, utilised pyrolysis technology to convert incontinence products into biochar, but only diverted 16 tonnes of waste (Egan, 2023; Med-X, 2023). With the disposal costs of sending incontinence waste to landfill estimated at $5.6 million annually across Australia in 2023 (Australian Circular Economy Hub, 2023), there was potential to decrease costs for aged care facilities through Project Divert. However, the project did not continue beyond the pilot phase.

DiaperRecycle, a Melbourne-based company operating since 2019 recycle, converts used nappy products into cat litter. By 2025, the company reportedly serviced approximately 500 households and processed around 1,500 kg of waste each week. The company claims its process produces 80.6% fewer greenhouse gas emissions than landfill disposal and generates a commercially competitive product (DiaperRecycle, 2021).

Super Faiths Inc. in Japan converts used products into pellet fuel for biomass boilers (Super Faiths Inc., 2026), while PHS Life Cycle in the United Kingdom processes more than 55,000 tonnes of hygiene waste annually into refuse-derived fuel used for electricity generation (PHS Group, 2023). However, approximately half of refuse-derived fuel generated from AHP waste consists of plastics (Scherer, 2025), and combustion releases greenhouse gases and air pollutants (Abd Halim et al., 2025). Consequently, waste-to-energy solutions may substitute one environmental burden for another.

Knowaste International developed technology capable of separating AHP waste into cellulose fibre and plastic pellets (Knowaste, 2026), but commercial operations ultimately ceased. More recently, the Embraced project in Italy established a facility capable of processing 10,000 tonnes of AHP waste annually and recovering cellulose, plastics, and superabsorbent polymers for reuse (Angelini Industries, 2020; Circular Bio-Based Europe, 2023). For every 100 kg of waste produced, 15kg of cellulose, 7.5 kg of plastic, and 7.5kg of superabsorbent polymer can be recovered (Embraced Project, 2020). The process relies on the separate collection of AHP waste from all other municipal waste in specialised bins strategically placed in public spaces. Following collection, the waste undergoes an autoclave treatment process, during which it is sanitised, separated into components, and dried (Interreg Europe, 2020).

The only example of true circularity is Unicharm's RefF product line in Japan, which incorporates recovered fluff pulp from used nappies into newly manufactured absorbent products.

More novel approaches have included using AHP waste as a substrate for cultivation of the oyster mushroom *Pleurotus ostreatus*, reducing waste volume by approximately 90% while producing pathogen-free biomass (Espinosa-Valdemar et al., 2011). Additionally, a Wales-based project incorporated recovered fibers into asphalt production (Nappicycle, 2026; Webb, 2022). Research suggests that inclusion of these fibres does not compromise road quality (Guo et al., 2023). Most recently, a collaboration between Essity, BASF, and the Technical University of Vienna (Chem Analyst, 2025) demonstrated that gasification of AHP waste above 800°C could generate purified carbon monoxide and hydrogen suitable for use as chemical feedstocks (Essity, 2026; McIntyre & Nonwovens Industry, 2025).

Discussion

The environmental sustainability of absorbent hygiene products used for adult incontinence is inseparable from broader debates about the sustainability of materials manufacturing globally, international environmental industry standards, Australian-based industry and manufacturing, the environmental neutrality of landfills, whether plastic and fibre recycling feasibility, and management of hazardous biological waste.

The most pressing environmental concern is not waste disposal, but manufacturing. The primary inputs for AHP manufacturing are produced overseas under regulatory frameworks and ecological conditions that Australia has limited capacity to influence. This means that most of the environmental damage associated with incontinence products used in Australia, including greenhouse gas emissions, toxic chemical outputs, water use, and land degradation, occurs overseas. The environmental impact is therefore not counted as Australian and neither government nor industry is currently incentivized to address it.

Within Australia, waste disposal is the more tractable policy lever. Nearly all used incontinence AHP waste is currently sent to landfill as municipal solid waste. This leads to anaerobic decomposition of bio-based components, generating methane and contributing to Australia's greenhouse gas emissions, while leachate from landfills containing human waste poses a risk to groundwater quality and nearby aquatic and terrestrial ecosystems. That approximately half of Australia's landfills lack adequate leachate or biogas collection systems further amplifies this risk. These products take between 150 and 500 years to decompose, and the ecological consequences of continued landfilling, methane emissions, leachate contamination, and the long-term accumulation of non-biodegradable materials, are significant even if they do not immediately threaten the operational continuity of Australian continence care.

Internationally, a variety of alternative disposal methods have been trialed, including composting, anaerobic digestion, pyrolysis, gasification, and direct material recovery. The City of Toronto's Green Bin program, which has included AHP waste since 2002, shows that large-scale diversion from landfill is operationally feasible, yielding both clean compost and renewable natural gas. The Nappy Loop pilot conducted by Kimberly-Clark in partnership with CSIRO demonstrated that composting of AHP waste is achievable in an Australian context, producing high-quality compost with no plastic contamination. More recently, a collaborative gasification project involving Essity, BASF, and the Technical University of Vienna has shown that processing AHP waste above 800°C can yield purified carbon monoxide and hydrogen gas that match the quality of virgin chemical feedstocks.

Recycling is not automatically a more sustainable option than virgin material production; it requires energy, purpose-built infrastructure, separate waste collection, and sterilization processes to manage the significant human waste component of AHP products. Many initiatives that have been trialled globally have not proven economically sustainable over the long term, have not scaled beyond pilot conditions, or have made environmental claims that do not account for the full energy and resource costs of their operations.

Where recycling does offer clear potential is in reducing the upstream environmental burden of raw materials production, which accounts for the majority of AHP environmental impact across nearly all measured categories. Recovering superabsorbent polymer, fluff pulp, or plastics from used products for reuse in manufacturing, whether of new AHPs or other products, directly reduces demand for virgin materials and the emissions associated with their production. While it is economically inefficient to conduct horizontal recycling, that is, converting the raw materials of AHPs back into AHPs; recycled materials can be reused in other products that require SAP, fibre or plastics. for each technology and in each operational context, it must be investigated whether the benefit of recycling outweighs the energy and resource costs of the recovery process.

A further consideration is the relationship between product design and environmental impact. Life cycle assessment data suggests that shifting from all-in-one products to pad-based products where clinically appropriate could reduce environmental impact by between 17% and 50%, depending on the assessment framework used. Ensuring that individuals use products appropriately sized to their continence needs, rather than larger or more absorbent products than required, can reduce material use and waste volume. Many Australians living with incontinence do not seek healthcare services, which means that most individuals are making product choices without clinical guidance. Addressing this barrier requires investment in public health communication and healthcare access, not simply changes to product design or disposal systems. Furthermore, while reducing unnecessary product use is a valuable intervention, these products remain essential. With Australia's population both ageing and growing, the prevalence of incontinence and the total volume of AHP waste will continue to increase regardless of efficiency gains at the individual level.

The sustainability of bio-based and biodegradable materials is highly dependent on the context of local waste-disposal systems, rather than being a fixed value. The environmental impact of bio-based materials is highly dependent on the production systems used, the land and water inputs required, and the disposal pathway available. Bio-based SAPs have demonstrated a higher ecological footprint than their synthetic equivalents in some studies. A bio-based product that ends up in an anaerobic landfill will generate methane while decomposing; its benefit over a conventional product is only realized if an appropriate disposal pathway, such as composting, is available and used. This means that decisions about material composition and decisions about disposal infrastructure are not independent and must be developed in concert. Additionally, there is also a significant gap in knowledge about the specific chemicals used in adult incontinence products, their environmental fate, and their potential to contaminate soils, groundwater, and aquatic ecosystems through leachate or manufacturing effluent. Until this information about specific brands and products is available, it is not possible to make well-informed recommendations about which products or materials are most sustainable. Additionally, understanding all chemical components is crucial to assess the feasibility of alternative disposal methods. When decisions are made about landfill standards, chemical regulations, recycling programs, or supply chain sustainability requirements, the waste challenge of AHPs must be independently addressed. AHPs do not fit neatly into the existing categories used to manage either green waste, recyclable materials, or hazardous substances, and these products require specialized management.

AHPs enable people living with incontinence to maintain dignity, participate in work and social life, and manage their health. The next to providing sustainable continence care in Australia is conducting the research to understand the composition and environmental impact of a range of AHPs.

References

ABC. (2022, December 6). “Quality sludge”: Dirty nappy recycling program stopping waste going to waste. *ABC News*. https://www.abc.net.au/news/2022-12-07/nappy-recycling-program-to-reduce-plastic-waste-in-landfill/101737628

Abd Halim, N. Y., Muhammad, N. I. S., Mansur, F. Z., & Ahmad, N. (2025). Sustainable fuel from agricultural waste: Mixture design optimization of refuse-derived fuel for enhanced energy output. *Next Sustainability*, *6*, 100196. https://doi.org/10.1016/j.nxsust.2025.100196

Angelini Industries. (2020, February 4). *Pampers Nuova Vita: from Fater a pilot project to collect and recycle wasted absorbent products*. Angeliniindustries.com. https://www.angeliniindustries.com/en/press-room/press-releases-and-news/news/pampers-nuova-vita-from-fater-a-pilot-project-to-collect-and-recycle-wasted-absorbent-products/

Arlington, K. (2013, October 2). *Dirty nappies? You might be sitting on them*. The Sydney Morning Herald. https://www.smh.com.au/environment/dirty-nappies-you-might-be-sitting-on-them-20131002-2usm5.html

Arquillos, L., Davies, P., Colbach, H., & Albessard, E. (2007). EDANA Sustainability Report 2007-2008, Absorbent Hygiene Products. In *ResearchGate*. EDANA. https://www.researchgate.net/publication/278390827_EDANA_Sustainability_Report_2007-2008_Absorbent_Hygiene_Products

Arumugam, A., S. Ariharasudhan, Babu, V. Ramesh., & sundaresan. (2024). Environmental impact of superabsorbent polymers - a comprehensive review. *ResearchGate*, *74*(1/2024), 24–26. https://www.researchgate.net/publication/378830254_Environmental_impact_of_superabsorbent_polymers_-_a_comprehensive_review

Arunraj, A., Ariharasudhan, S., Babu, V., & Sundaresan, S. (2024). *Environmental impact of superabsorbent polymers - a comprehensive review*.

Australian Ageing Agenda. (2012, May 31). *Continence aid recycling wins business award - Australian Ageing Agenda*. Australian Ageing Agenda. https://www.australianageingagenda.com.au/noticeboard/continence-aid-recycling-wins-business-award/

Australian Circular Economy Hub. (2023). *World-first solution dealing with aged care waste*. Acehub.org.au. https://acehub.org.au/news/world-first-solution-dealing-with-aged-care-waste

Australian Drinking Water Guidelines. (2026). *Welcome To Zscaler Directory Authentication*. Nhmrc.gov.au. https://guidelines.nhmrc.gov.au/australian-drinking-water-guidelines/part-5/physical-chemical-characteristics/dichlorobenzenes

Australian Strategic Policy Institute. (2024, May 7). *Helium, polyethylene and more: Australia loses basic-materials industries*. The Strategist. https://www.aspistrategist.org.au/helium-polyethylene-and-more-australia-loses-basic-materials-industries/

Bartels, V. T., & Manchester, I. (2011). *Handbook of medical textiles*. Woodhead Pub.

Blue Environment Pty Ltd. (2013). *Analysis of landfill survey data Final report prepared for Waste Management Association of Australia*. https://www.dcceew.gov.au/sites/default/files/documents/landfill-survey-data.pdf

Blue Environment Pty Ltd. (2022). *National Waste Report 2022*. https://www.dcceew.gov.au/sites/default/files/documents/national-waste-report-2022.pdf

Bou Kheir, G., Rantell, A., Hentzen, C., Papaefstathiou, E., Van den Ende, M., Da Silva, A. S., Wyndaele, M., Van Huele, A., Sinha, S., & Abrams, P. (2025). What Data Do We Need to Show the Cost and Clinical Effectiveness, Bearing in Mind Sustainability, of Urological

Disposables in Different Patient Groups? ICI-RS 2025. *Neurourology and Urodynamics*, 10.1002/nau.70174. https://doi.org/10.1002/nau.70174

Cha, S.-J. (2023). Commercially Available Incontinence Pads and Requirement Analysis. *Journal of the Korea Society of Computer and Information*, *28*(6), 89–102. https://doi.org/10.9708/jksci.2023.28.06.089

Chem Analyst. (2025). *BASF, Essity and TU Wien Pioneer Circular Recycling of Absorbent Hygiene Products Through Innovative Gasification Technology | ChemAnalyst*. Chemanalyst.com. https://www.chemanalyst.com/NewsAndDeals/NewsDetails/basf-essity-and-tu-wien-pioneer-circular-recycling-of-absorbent-hygiene-products-40387

Circular Bio-Based Europe. (2023, June 26). *Establishing a multi-purpose biorefinery to recycle organic content | Circular Bio-based Europe Joint Undertaking (CBE JU)*. Europa.eu. https://www.cbe.europa.eu/achievements/establishing-multi-purpose-biorefinery-recycle-organic-content

City of Toronto. (2017a, November 16). *What Goes in the Green Bin (Organics)?* City of Toronto. https://www.toronto.ca/services-payments/recycling-organics-garbage/houses/what-goes-in-my-green-bin/

City of Toronto. (2017b, November 16). *What Happens to Organics?* City of Toronto. https://www.toronto.ca/services-payments/recycling-organics-garbage/houses/what-happens-to-organics/

Continence Foundation of Australia. (2021). *Understanding incontinence*. Continence Foundation of Australia. https://www.continence.org.au/incontinence/understanding-incontinence

Continence Health Australia. (2026, March 30). *Statistics on incontinence - Continence Health Australia*. Continence Health Australia. https://www.continence.org.au/about-incontinence/what-is-incontinence/statistics-on-incontinence/

Cordella, M., Bauer, I., Lehmann, A., Schulz, M., & Wolf, O. (2015). Evolution of disposable baby diapers in Europe: life cycle assessment of environmental impacts and identification of key areas of improvement. *Journal of Cleaner Production*, *95*, 322–331. https://doi.org/10.1016/j.jclepro.2015.02.040

Cottenden, A. M. (1988). Incontinence pads: clinical performance, design and technical properties. *Journal of Biomedical Engineering*, *10*(6), 506–514. https://doi.org/10.1016/0141-5425(88)90108-2

Denagbe, W., Mazet, E., Desbrières, J., & Michaud, P. (2025). Superabsorbent polymers: Eco-friendliness and the gap between basic research and industrial applications. *Reactive and Functional Polymers*, *214*, 106278. https://doi.org/10.1016/j.reactfunctpolym.2025.106278

Department of Climate Change, Energy, the Environment and Water. (2022). *Recovering organic waste - DCCEEW*. Dcceew.gov.au. https://www.dcceew.gov.au/environment/protection/waste/food-waste/recovering-organic-waste

DiaperRecycle. (2021). *About*. DiaperRecycle, Kelland Environmental Technology Pty Ltd. https://diaperrecycle.com/about/

Dunse, B., Trudinger, C., Derek, N., Fraser, P., & Krummel, P. (2025). *Australian and Global Emissions of Ozone Depleting Substances*.

Edana. (2025). *Adult Incontinence products composition*. Edana.org. https://www.edana.org/how-we-take-action/product-safety/adult-incontinence-products-composition

Egan, N. (2023, April 4). *Pad recycling trial reaches milestone - Australian Ageing Agenda*. Australian Ageing Agenda. https://www.australianageingagenda.com.au/facility-operations/pad-recycling-trial-reaches-milestone/

Embraced Project. (2020). *Establishing a multi-purpose biorefinery for the recycling of the organic content of Absorbent Hygiene Products waste in a circular economy domain*. https://www.embraced.eu/repository/Booklet_Embraced.pdf

Environment Agency. (2005). *Life Cycle Assessment of Disposable and Reusable Nappies in the UK*. https://assets.publishing.service.gov.uk/media/5a7c4096ed915d7d70d1d993/scho0505bjcw-e-e.pdf

Environment Victoria. (2017, September 4). *Organic waste*. Environment Victoria. https://environmentvictoria.org.au/resource/organic-waste/

Espinosa-Valdemar, R., Turpin-Marion, S., Delfín-Alcalá, I., Vazquez, A. (2011) *Disposable diapers biodegradation by the fungus Pleurotus ostreatus* August 2011 *Waste Management* 31(8):1683-8 https://DOI.org/10.1016/j.wasman.2011.03.007

Espinosa-Valdemar et al (2015) *Assessment of Gardening Wastes as a Co-Substrate for Diapers Degradation by the Fungus Pleurotus ostreatus Sustainability* 2015, 7(5), 6033-6045; https://doi.org/10.3390/su7056033

Espinosa-Valdemar, R. M., Sotelo-Navarro, P. X., Quecholac-Piña, X., García-Rivera, M. A., Beltrán-Villavicencio, M., Ojeda-Benítez, S., & Vázquez-Morillas, A. (2014). Biological recycling of used baby diapers in a small-scale composting system. *Resources, Conservation and Recycling*, *87*, 153–157. https://doi.org/10.1016/j.resconrec.2014.03.015

Essity. (2026). *Essity, BASF and Technical University of Vienna achieve successful diaper recycling pilot*. Essity.com. https://www.essity.com/media/news-features/2025/successful-diaper-recycling-pilot/

European Commission. (2017, June). *Creating sustainable value from used nappies*. EC R&I Success Stories. https://projects.research-and-innovation.ec.europa.eu/en/projects/success-stories/all/creating-sustainable-value-used-nappies

Garcia, J. A., Crocker, J., & Wyman, J. F. (2005). Breaking the Cycle of Stigmatization: Managing the Stigma of Incontinence in Social Interactions. *Journal of Wound Ostomy & Continence Nursing*, *32*(1), 38. https://journals.lww.com/jwocnonline/abstract/2005/01000/breaking_the_cycle_of_stigmatization__managing_the.9.aspx

Geoscience Australia. (2025, October 23). *Oil*. Geoscience Australia. https://www.ga.gov.au/aecr2025/oil

Gosden, D., Studley, M., & Rossiter, J. (2023). Material extrusion of sodium polyacrylate superabsorbent polymer. *Additive Manufacturing*, *78*, 103886. https://doi.org/10.1016/j.addma.2023.103886

Gu, X., Sun, M., Long, X., Deng, H., & Wang, Y. (2023). Environmental impact of adult incontinence products in China in the context of population aging. *Science of the Total Environment*, *875*, 162596. https://doi.org/10.1016/j.scitotenv.2023.162596

Gunarathne, V., Phillips, A. J., Zanoletti, A., Rajapaksha, A. U., Vithanage, M., Di Maria, F., Pivato, A., Korzeniewska, E., & Bontempi, E. (2024). Environmental pitfalls and associated human health risks and ecological impacts from landfill leachate contaminants: Current evidence, recommended interventions and future directions. *Science of the Total Environment*, *912*, 169026. https://doi.org/10.1016/j.scitotenv.2023.169026

Guo, Y., Piergiorgio Tataranni, & Sangiorgi, C. (2023). The use of fibres in asphalt mixtures: A state of the art review. *The Use of Fibres in Asphalt Mixtures: A State of the Art Review*, *390*, 131754–131754. https://doi.org/10.1016/j.conbuildmat.2023.131754

Holdway, R., & Dowling, M. (2023). *Life Cycle Assessment of Disposable and Reusable Nappies in the UK 2023 Defra project reference: EV0493*. https://www.suffolkrecycling.org.uk/Asset-library/15724-ev0493-nappy-lca-report-final.pdf

Hristova, K. (2025). Disruption in the Supply Chain of Absorbent Hygiene Products—Causes and Risks. *Advances in Science, Technology & Innovation*, 349–355. https://doi.org/10.1007/978-3-031-90131-7_40

Independence Australia. (2026). *Independence Australia Online*. Independence Australia. https://www.independenceaustralia.com.au/

Interreg Europe. (2020). *Fater SMART - Diaper Recycling*. Interregeurope.eu. https://www.interregeurope.eu/good-practices/fater-smart-diaper-recycling

Shah et el (2025) *Towards a greener future of sustainable and circular practices in resource recovery from discarded disposable diaper (D3): a systematic review and meta-analysis* Journal of Material Cycles and Waste Management (2025) 27:3033–3054 https://doi.org/10.1007/s10163-025-02277-6

Jassal, M., & Textile Institute (Manchester, England. (2011). *Textiles for hygiene and infection control*. Woodhead Pub.

Johns Hopkins Medicine. (2026). *Urinary Incontinence*. Www.hopkinsmedicine.org. https://www.hopkinsmedicine.org/health/conditions-and-diseases/urinary-incontinence

Kakonke, G., Tesfaye, T., Sithole, B., & Ntunka, M. (2019). Iss 1 Review on the Manufacturing and Properties of Nonwoven Superabsorbent Core Fabrics used in Disposable Diapers. *International Journal of Chemical Sciences Review*, *17*(1), 302. https://doi.org/10.21767/0972-768X.1000302

Knowaste. (2026). *Knowaste History*. Knowaste.com. http://www.knowaste.com/knowaste-history.html

Kumar, A., Nguyen, H., Nguyen, T., Muster, T., & CSIRO Environment. (2023). *Turning Waste to Value: Harnessing Benefits from Recycled Nappy SAP*.

Kusumawati, D. I., & Mangkoedihardjo, S. (2021). Promising approach for composting disposable diapers enhanced by Cyanobacteria. *Global Journal of Environmental Science and Management*, *7*(3), 439–456. https://doi.org/10.22034/GJESM.2021.03.08

Li, D. (2022, December 7). *G8 partners in Australian-first nappy recycling trial - G8 Education*. G8 Education. https://g8education.edu.au/news/g8-nappy-loop-recycling-trial

Ma, N. L., Khoo, S. C., Peng, W., Ng, C. M., Teh, C. H., Park, Y.-K., & Lam, S. S. (2020). Green application and toxic risk of used diaper and food waste as growth substitute for sustainable cultivation of oyster mushroom (Pleurotus ostreatus). *Journal of Cleaner Production*, *268*, 122272. https://doi.org/10.1016/j.jclepro.2020.122272

Market Data Forecast. (2024, June 16). *Disposable Incontinence Products Market*. Market Data Forecast. https://www.marketdataforecast.com/market-reports/disposable-incontinence-products-market

Mascariñas, L. R. A., Ureta, R. M., Mejico, S. M., & Servando, C. D. (2019). Elaboration and Characterization of Thermal Insulating Material Based on the Synergy of Natural Coconut Husk and Disposable Diaper Pads Fibers. *International Journal of Engineering and Technologies*, *17*, 21–32. https://doi.org/10.18052/www.scipress.com/ijet.17.21

McIntyre, K., & Nonwovens Industry. (2019, February 19). *Pilot Diaper Recycling Program Underway in Amsterdam*. Nonwovens Industry. https://www.nonwovens-industry.com/breaking-news/pilot-diaper-recycling-program-underway-in-amsterdam/

Med-X. (2023, March 17). *Australian-First Trial for Aged Care Waste Problem | Med-X*. Med X Solutions. https://www.med-xsolutions.com.au/australian-first-trial-for-aged-care-waste-problem/

Mendoza, J. M. F., D'Aponte, F., Gualtieri, D., & Azapagic, A. (2019). Disposable baby diapers: Life cycle costs, eco-efficiency and circular economy. *Journal of Cleaner Production*, *211*, 455–467. https://doi.org/10.1016/j.jclepro.2018.11.146

Mirabella, N., Castellani, V., & Sala, S. (2013). Life cycle assessment of bio-based products: a disposable diaper case study. *The International Journal of Life Cycle Assessment*, *18*(5), 1036–1047. https://doi.org/10.1007/s11367-013-0556-6

Moore, J. E., Mascarenhas, A., Bain, J., & Straus, S. E. (2017). Developing a comprehensive definition of sustainability. *Implementation Science*, *12*(1). https://doi.org/10.1186/s13012-017-0637-1

Muthu, S. S., Ng, F. S. F., Li, Y., Hui, P. C. L., & Guo, Y. (2013). Carbon and eco-footprints of adult incontinence products. *Fibers and Polymers*, *14*(10), 1776–1781. https://doi.org/10.1007/s12221-013-1776-x

Nappicycle. (2026). *Innovations – NappiCycle*. Nappicycle. https://www.nappicycle.co.uk/innovations/

National Transport Commission. (2022, September 15). *Light vehicle emissions intensity in Australia*. Www.ntc.gov.au. https://www.ntc.gov.au/light-vehicle-emissions-intensity-australia

Night N Day Group. (2025). *About Night n Day Group - Our Story Since 1989*. Nightndaygroup.com.au. https://www.nightndaygroup.com.au/about-us

NSW EPA. (2021). *Landfill Consolidation and Environmental Improvements Grants Program | EPA*. EPA. https://www.epa.nsw.gov.au/Working-together/Grants/councils/landfill-consolidation-and-environmental-improvements-grants-program

O'brien, K., Olive, R., Hsu, Y.-C., Morris, L., Bell, R., & Kendall, N. (2009). *LIFE CYCLE ASSESSMENT: REUSABLE AND DISPOSABLE NAPPIES IN AUSTRALIA*. https://www.ecorisparmiare.it/blog/wp-content/uploads/2019/11/44777470.pdf

Ontex. (2025, May 8). *Eastern creek*. Ontex. https://ontex.com/company/our-presence/eastern-creek/

Paterson, M. (2023). *Inquiry into the waste management of absorbent hygiene products*. https://www.parliament.act.gov.au/__data/assets/pdf_file/0020/2171351/019-Kimberly-Clark-Australia.pdf

PHS Group. (2023). *LifeCycle Strategy: Transforming Waste Management - phs*. Phs.co.uk; LifeCycle Strategy: Transforming Waste Management - phs. https://www.phs.co.uk/phs-lifecycle-strategy/

Pickin, J. (2013). *Analysis of landfill survey data Final report prepared for Waste Management Association of Australia*. https://www.dcceew.gov.au/sites/default/files/documents/landfill-survey-data.pdf

Scherer, G. (2025, December 10). *Boom in burning waste for fuel puts human health and environment at risk*. Conservation News. https://news.mongabay.com/2025/12/boom-in-burning-waste-for-fuel-puts-human-health-and-environment-at-risk/

Smithers. (2016). *Fluff pulp market maintains steady growth*. Smithers. https://www.smithers.com/resources/2024/july/fluff-pulp-market-maintains-steady-growth

Subhankar Maity, Kunal Singha, & Pandit, P. (2023a). Introduction to functional and technical textiles. *Elsevier EBooks*, 1–30. https://doi.org/10.1016/b978-0-323-91593-9.00021-3

Super Faiths Inc. (2026). *Super Faiths Inc. | SFD System*. Superfaiths.com. http://superfaiths.com/english/sfd.html

Thompson Brewster, E., Rounsefell, B., Lin, F., Clarke, W., & O’Brien, K. R. (2022). Adult incontinence products are a larger and faster growing waste issue than disposable infant nappies (diapers) in Australia. *Waste Management*, *152*, 30–37. https://doi.org/10.1016/j.wasman.2022.07.038

Tiina Vaittinen, Koljonen, K., Tella, S., Eveliina Asikainen, & Katri Laatikainen. (2023). Holistically sustainable continence care: A working definition, the case of single-used absorbent hygiene products (AHPs) and the need for ecosystems thinking. *Proceedings of the Institution of Mechanical Engineers. Part H, Journal of Engineering in Medicine*. https://doi.org/10.1177/09544119231188860

Torrijos, M., Sousbie, P., Rouez, M., Lemunier, M., Lessard, Y., Galtier, L., Simao, A., & Steyer, J. P. (2014). Treatment of the biodegradable fraction of used disposable diapers by co-digestion with waste activated sludge. *Waste Management*, *34*(3), 669–675. https://doi.org/10.1016/j.wasman.2013.11.009

V. S., B. S., Gujjala, L. K. S., & Althuri, A. (2025). A review on superabsorbent polymers: application and recent advances in environmental and economic profiling. *Discover Applied Sciences*, *7*(11). https://doi.org/10.1007/s42452-025-07477-1

Vaughan, C. P., Goode, P. S., Burgio, K. L., & Markland, A. D. (2011). Urinary Incontinence in Older Adults. *Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine*, *78*(4), 558–570. https://doi.org/10.1002/msj.20276

Viva Energy. (2023). *Polymers - Viva Energy Australia*. Vivaenergy.com.au. https://www.vivaenergy.com.au/business/polymers

Webb, S. (2022, February 24). *Potty holes: Dirty nappies used to resurface road*. The Independent. https://www.independent.co.uk/climate-change/news/nappies-recycling-wales-climate-crisis-b2022371.html

Willskytt, S., & Tillman, A.-M. (2019). Resource efficiency of consumables – Life cycle assessment of incontinence products. *Resources, Conservation and Recycling*, *144*, 13–23. https://doi.org/10.1016/j.resconrec.2018.12.026

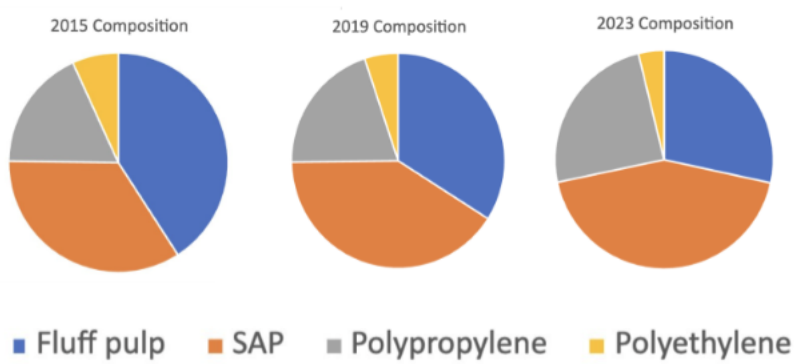
World Health Organization. (2021, September). *C40 Knowledge Community*. Www.c40knowledgehub.org. https://www.c40knowledgehub.org/s/article/WHO-Air-Quality-Guidelines?language=en_US

Ximenes, F. A., Gardner, W. D., & Cowie, A. L. (2008). The decomposition of wood products in landfills in Sydney, Australia. *Waste Management*, *28*(11), 2344–2354. https://doi.org/10.1016/j.wasman.2007.11.006

Yang, X., Wu, X., Hao, H., & He, Z. (2008). Mechanisms and assessment of water eutrophication. *Journal of Zhejiang University SCIENCE B*, *9*(3), 197–209. https://doi.org/10.1631/jzus.b0710626

Zekry, M., Salim, H., Nassar, I., & Abdallah, A. (2022). *Recycling of disposable baby diapers for enhancing the growth and survival of Eucalyptus seedlings subjected to drought*.

Figure 1: *Overall Material Composition of an Average Infant Nappy in 2015, 2019 and 2023*



Note: data extracted from Cordella et al (2015), Mendoza et al, 2019) and Holdway & Dowling, 2023)

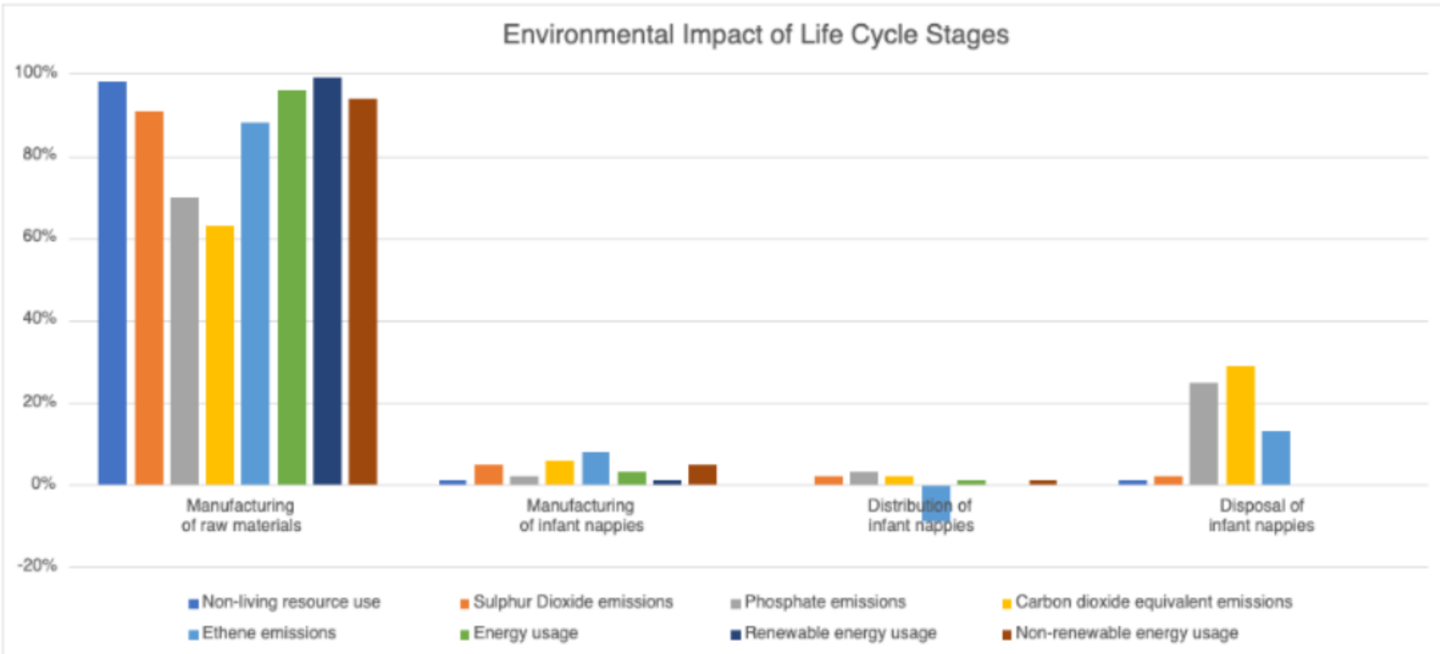
Input per nappy	Unit	Amount	%
Fluff pulp	g	8.34	25.66%
Super absorbent polymer (SAP)	g	13.22	39.09%
PP	g	7.49	22.15%
PE	g	1.16	3.43%
LDPE	g	0.39	1.14%
PET	g	0.069	0.20%
Polyester	g	0.26	0.78%
Elastic	g	1.13	3.34%
Glue/Adhesives	g	1.18	3.49%
Calcium carbonate	g	0.19	0.55%
Tape	g	0.37	1.08%
Lotion	g	6.95E-03[7]	0.02%
Other	g	0.02	0.05%
Total weight	**g**	**33.816**	**100%**

Table 1: Material composition of disposable nappies

Table 1 is taken from Holdway & Dowling 2023

Either new Figure 1 with 2023 only or Table 1 as above?

Figure 2: Environmental impact of life cycle stages of the average infant nappy on the European market in 2011



(New) Figure 1 Disposable nappy carbon footprint (kgCO2e-)

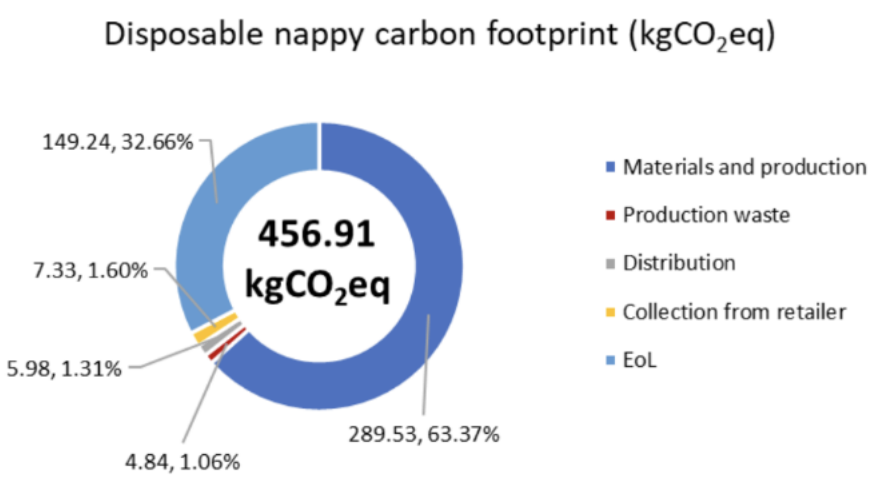
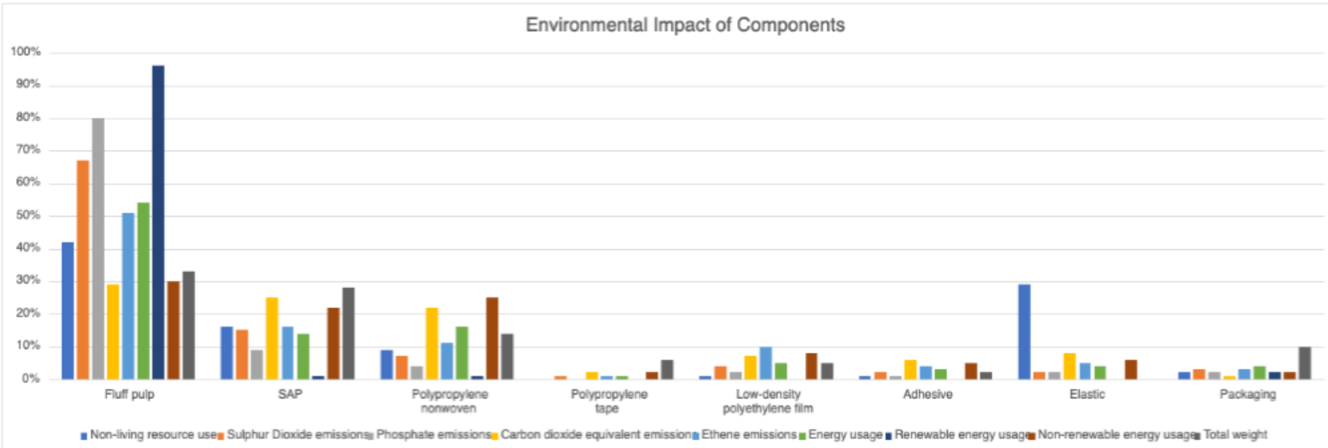


Figure 1: Disposable nappy environmental impact ($KgCO_2eq$)

Figure 1 is taken from Holdway & Dowling 2023

Figure 3: Environmental Impact of Nappy Materials Based on the Average Infant Nappy on the European Market in 2011



Note. Data extracted from (Cordella et al, 2015)

Table 4
Breakdown of the environmental impacts of materials for an average disposable baby diaper in Europe in 2011.

Indicator	Fluff pulp	SAP	PP nonwoven	PP tape	LDPE film	Adhesive	Elastic	Packaging
ADP elements	42%	16%	9%	0%	1%	1%	29%	2%
AP	67%	15%	7%	1%	4%	2%	2%	3%
EP	80%	9%	4%	0%	2%	1%	2%	2%
GWP	29%	25%	22%	2%	7%	6%	8%	1%
POP	51%	16%	11%	1%	10%	4%	5%	3%
CED_T	54%	14%	16%	1%	5%	3%	4%	4%
CED_R	96%	1%	1%	0%	0%	0%	0%	2%
CED_{NR}	30%	22%	25%	2%	8%	5%	6%	2%
Total weight[a]	33%	28%	14%	6%	5%	2%	0%	10%

[a] Diaper + packaging.

ADP, abiotic depletion potential
AP, acidification potential
EP, eutrophication potential
GWP, global warming potential
POP, photochemical oxidation potential
CEDT, cumulative energy demand for the total amount of energy resources
CEDR, cumulative energy demand for renewable energy resources
CEDNR, cumulative energy demand for non-renewable energy resources

Table 1 Human health impacts of materials, production and disposal of AHPs

Metric	**Total impact**	**Materials and production**	**Disposal**
Ozone formation, human health	840g eq NOx	88%	7%

Human carcinogenic toxicity	17.38 kg 1,4-DCB	52%	42%
Non-carcinogenic toxicity	469.62 kg 1,4-DCB	97%	1%

Table 2 Environmental impacts of materials, production and disposal of AHPs

Metric	Impact	Materials and production	Disposal
Global warming potential	456.91 kg CO2	69%	25%
Stratospheric ozone depletion	2.29E-04 kg CFC11	100%	-1%
Fine particulate matter formation	0.44 kg PM2.5 eq	76%	16%
Ozone formation	870 kg NOx eq	88%	7%
Terrestrial acidification	1.00 kg SO2 eq	75%	22%
Freshwater eutrophication	0.22 kg P eq	25%	73%
Marine eutrophication	0.06 kg N eq	66%	16%
Terrestrial ecotoxicity	1879.16 kg 1,4-DCB	40%	54%
Freshwater ecotoxicity	23.91 kg 1,4-DCB	40%	54%
Marine ecotoxicity	32.84 kg 1,4-DCB	79%	13%

Note: This data was sourced from the 2023 report by Holdway & Dowling, *"Life Cycle Assessment of Disposable and Reusable Nappies in the UK 2023"*

(New) Table 2 Human and environmental impacts of materials, production and disposal of AHPs

Impacts on human health	**Measure of total impact**	**Life Cycle Stages** **- Materials / Production** **- Disposal** **- Other**	**Normalisation**	
			Standard annual reference (per person/year)	**Relative severity / equivalence**

Ozone formation	840g eq NOx	88% 7% 5%	~35 to 40 kg NO_{x} eq	~1 week of an average person's total annual smog impact.
Human carcinogenic toxicity	17.38 kg 1,4-DCB	52% 42% 6%	~40 to 50 kg 1,4-DCB eq	~4 months of an average person's total annual cancer-risk footprint.
Non-carcinogenic toxicity	469.62 kg 1,4-DCB	97% 1% 2%	~250 to 300 kg 1,4-DCB eq / person	~1.5 to 1.8 years of an average person's annual systemic health footprint.
Impacts on environmental health	**Measure of total impact**	**Life Cycle Stages - Materials / Production** **- Disposal** **- Other**	**Normalisation**	
			Standard annual reference (per person/year)	**Relative severity / equivalence**
Global warming potential	456.91 kg CO2	69% 25% 6%	~7,000 to 8,500 kg CO_{2} eq	~3 weeks of an average person's footprint
Stratospheric ozone depletion	2.29E-04 kg CFC11	100% -1% 1%	0.0523 kg CFC-11 eq (52.3grams)	~1.6 Days of an average person's total annual footprint.
Fine particulate matter formation	0.44 kg PM2.5 eq	76% 16% 8%	~3.80 kg $\text{PM}_{2.5}$ eq	~6 Weeks of an average person's total annual footprint.
Ozone formation	870 Kg NOx eq	88% 7% 5%	~35 to 40 kg NO_{x} eq	~22 to 25 Years of an average person's footprint.
Terrestrial acidification	1.00 kg SO2 eq	75% 22% 3%	~150 to 250 kg 1,4-DCB	~8 to 12 Years of an average person's footprint.

Freshwater eutrophication	0.22 kg P eq	25% 73% 2%	~0.5 to 1.5 kg P eq	~2 months of an average person's footprint.
Marine eutrophication	0.06 kg N eq	66% 16% 18%	~50 to 70 kg 1,4-DCB	~6 months of an average person's footprint.
Terrestrial ecotoxicity	1879.16 kg 1,4-DCB	40% 54% 6%	~150 to 250 kg 1,4-DCB	~8 to 12 Years of an average person's footprint.
Freshwater ecotoxicity	23.91 kg 1,4-DCB	40% 54% 6%	~40 to 60 kg 1,4-DCB	~5 months of an average person's footprint.
Marine ecotoxicity	32.84 kg 1,4-DCB	79% 13% 8%	~50 to 70 kg 1,4-DCB	~6 months of an average person's footprint.

References:

LCA Data sourced from the 2023 report by Holdway & Dowling, *"Life Cycle Assessment of Disposable and Reusable Nappies in the UK 2023"*

Normalisation data derived from Andreasi Bassi, S., Biganzoli, F., Ferrara, N., Amadei, A., Valente, A. et al., Updated characterisation and normalisation factors for the environmental footprint 3.1 method, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2760/798894

Table notes:

CO_2, Carbon Dioxide, a naturally occurring gas that serves as the primary greenhouse gas emitted through human and industrial activities. –

CFC-11 stands for Trichlorofluoromethane, a halogenated organic compound containing carbon, chlorine, and fluorine atoms.

N, Nitrogen

NOx, Nitrogen Oxides, a highly reactive group of gases primarily composed of Nitrogen Dioxide (NO_2) and Nitric Oxide (NO)

P, Phosphorus

PM2.5, stands for Fine Particulate Matter, which refers to microscopic airborne particles or droplets that are 2.5 micrometers or smaller in width.

Sulfur Dioxide, a toxic, pungent gas composed of sulfur and oxygen atoms.

1,4-DCB, in environmental chemistry, 1,4-DCB refers to dichlorobenzene. This chemical acts as pollutants and poses a high environmental and health risk.

Nox, Nitrogen Oxides, a highly reactive group of gases primarily composed of Nitrogen Dioxide and Nitric Oxide

1,4-DCB

Table 3 Life Cycle Analysis of AHPs

	EPS LCA results	**ReCiPe LCA results**
Recycling unused waste generated during manufacturing	5% Reduction in environmental impact compared to incineration of waste	6% reduction in environmental impact
Utilizing a higher percentage of bio-based material	26% Reduction in environmental impact	4% reduction in environmental impact
Using pads in replacement of pants products	37% Reduction in environmental impact	17% reduction in environmental impact
Tailoring product size to the individual	21% Reduction in environmental impact	20% Reduction in environmental impact

Table: A 2019 life cycle assessment investigated possible interventions to reduce the environmental impact of absorbent hygiene products. These interventions were: (1) recycling the unused waste generated during manufacturing, (2) utilising a higher percentage of bio-based materials in AHP products, (3) using pads rather than pants products where possible, and (4) ensuring *that individuals are not using products of a larger size and absorption capacity than necessary by analysing individual incontinence severity and recommending the most suitable product. Source: (Willskytt & Tillman, 2019)*

(Alternative Table 3)

Table 3 Life Cycle Impact Assessment (LCIA) methodologies used to measure environmental impact of interventions

Intervention compared	**EPS LCA Results (% Reduction)**	**ReCiPe LCA Results (% Reduction)**
Recycling unused manufacturing waste	5%[1]	6%
Utilizing higher % of bio-based material	26%	4%
Replacing pants products with pads	37%	17%
Tailoring product size to the individual	21%	20%

[1] *Compared to incineration of waste.*

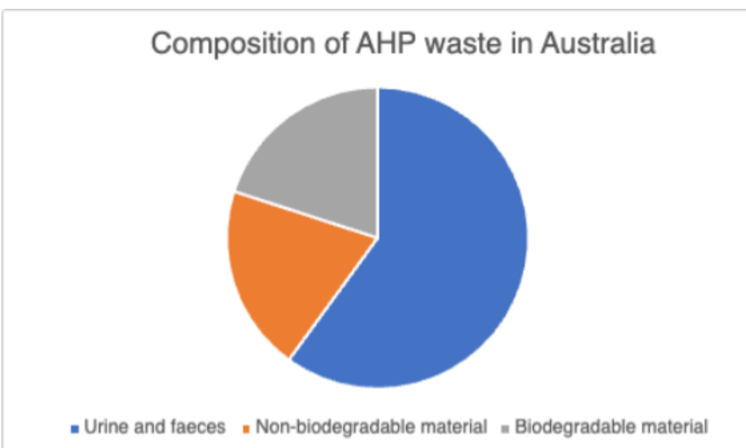
Table 4 Details of AHP products available on Independence Australia website 2026

Manufacturer / Brand	**Disposable products**	**Washable products**	**Brand/manufacturer location**
Abena	X		International
AMD	X		International
Bokers		X	Unclear
Bonds		X	Australia
Buddies		X	Australia
Cello Paper / Incohelp	X		Australia
Comfort by cottons / Cottons comforts	X		Australia
Conni		X	Australia
Eenee		X	Australian
Essity / Tena	X		International

First Quality / Prevail	X		International
Hartmann / Molicare	X		International
Kimberley Clark	X		International
Medline / Ultrasorb, Protection plus	X		International
Minappi / NightNDay	X	X	Australia
National Australian Nappies Pty Ltd / Active	X		Australia
Ontex / ID, Lille	X		International
StayDry		X	Australia

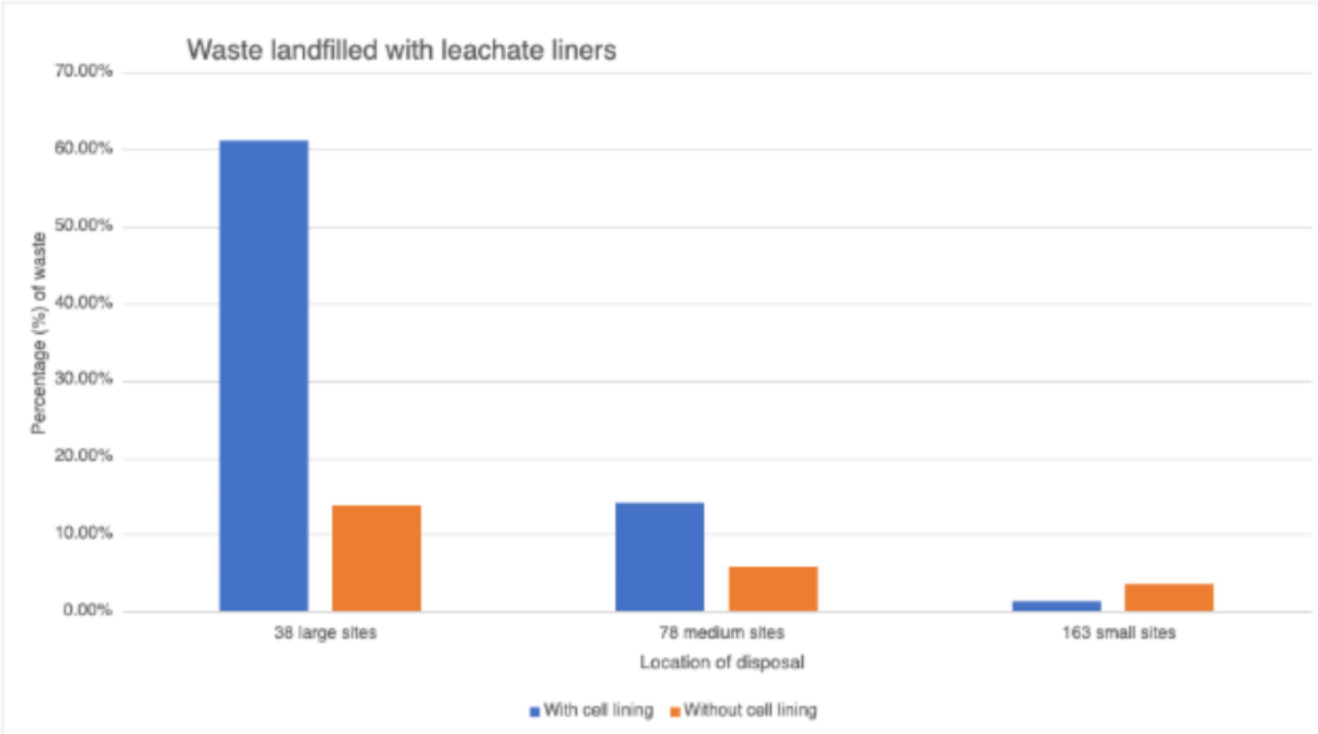
Note: The information in this table was sourced from the Independence Australia website in February 2026 and may be subject to change

Figure 4 *Composition of used AHP waste in Australia*



Note: Data sourced from (Thompson Brewster et al., 2022)

Figure 5 *Waste that goes to landfills with leachate liners compared with the waste that goes to landfills without leachate liners.*



Note: Data sourced from (Pickin, 2013) Analysis of survey landfill data.

Source: Pickin (2013) Analysis of landfill survey data Final report: P398. Accessed on Australian Government Department of Climate Change Energy Efficiency and Water (DCCEEW) website at https://www.dcceew.gov.au/sites/default/files/documents/landfill-survey-data.pdf

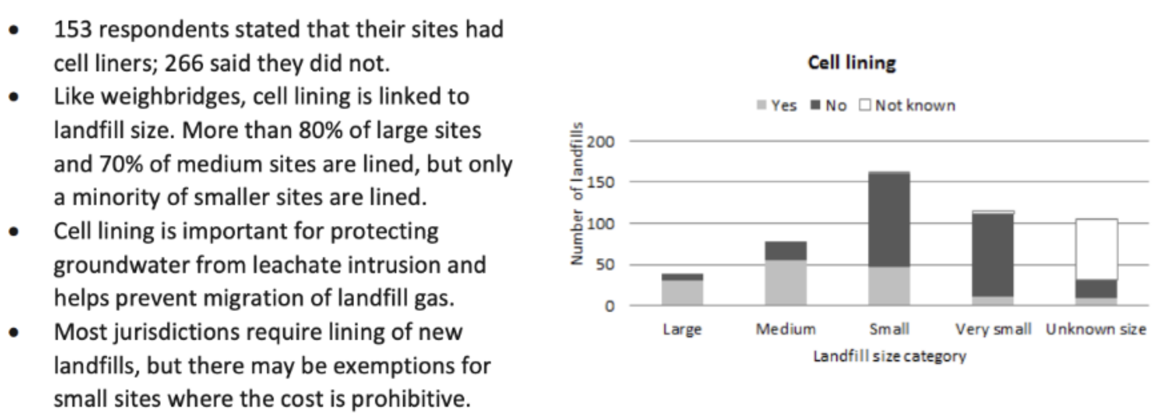
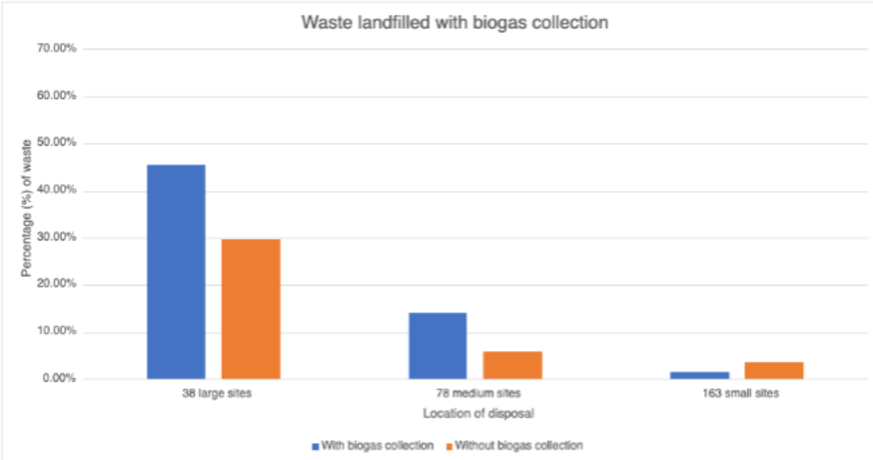


Figure 6 *Waste that goes to landfills with biogas collection compared with the waste that goes to landfills without biogas collection*



Source: Pickin (2013) Analysis of landfill survey data Final report: P398. Accessed on Australian Government Department of Climate Change Energy Efficiency and Water (DCCEEW) website at https://www.dcceew.gov.au/sites/default/files/documents/landfill-survey-data.pdf

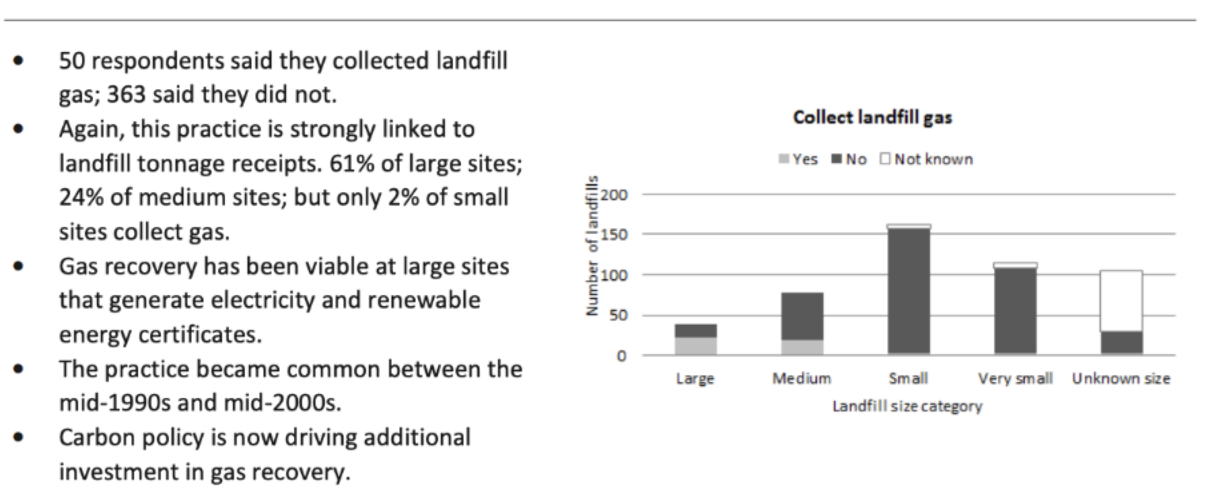


Table 11 *Novel Solutions for AHP Waste Disposal*

Use of waste	Mechanism of disposal for AHP	Successful trial	Successfully scaled

Gardening Wastes as a Co-Substrate for Diapers Degradation by the Fungus *Pleurotus ostreatus*	The mushroom has been shown to reduce the weight and volume of diapers by up to 90% over 3 months.	Yes	No
Thermal insulating material[2]	Tested in combination with natural coconut husk fibers for enhanced thermal insulating properties	Affirmed at lab-scale	No
Small-scale composting in Mexico[3]	Infant diapers were composted along with yard waste in 200L bioreactors.	Yes	No
Co-digestion with waste activated sludge[4]	Treatment of used disposable diapers permitting the recycling of materials and the recovery of energy	Yes	No
SAP used to enhance soil moisture and improve survival rates of Eucalyptus seedlings in drought[5]	Helped water retention and seedling survival, but increased soil salinity as a side-effect.	Yes	No
Composting with Spirulina plastensis[6]	Using compost as a medium for maize and cayenne pepper	Yes	No
Biohydrogen production through dark fermentation of the organic components of waste[7]	Used disposable diapers as a substrate for biohydrogen production.	Yes	No

Source: Shah et el (2025) *Towards a greener future of sustainable and circular practices in resource recovery from discarded disposable diaper (D3): a systematic review and meta-analysis* Journal of Material Cycles and Waste Management (2025) 27:3033–3054 https://doi.org/10.1007/s10163-025-02277-6