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Waste to wealth : A study on recycled and upcycled textiles

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Recycling and upcycling are the prominent sustainable practices that play a role in the reduction of waste. Upcycling is the process of transforming pre- or post-consumer textile waste into new clothing. In contrast, recycling converts waste into base materials used to manufacture new products. Due to its role in resource conservation and ability to divert massive quantities of textile waste from the trash stream, upcycling is growing in popularity among the textile and fashion designers.

Recycling and upcycling are critical steps towards sustainability because the textile and fashion industry has a detrimental environmental impact. Recycling materials and finished products can help the sector to reduce waste and pollution. Recycling helps to save natural resources such as water and virgin fibres by allowing the same materials to be used repeatedly. This not only



boosts the economy and creates job opportunities, but also helps these sectors to have a more sustainable future. By adopting recycling and

upcycling, the sector could move to a closed-loop model that supports the 'for all forever' notion in a world with limited resources.

Upcycling and recycling

Both recycling and upcycling are methods of decreasing waste and increasing sustainability,

although they use different approaches. Recycling involves reducing resources to their raw form and reusing them to make new goods. On the other hand, upcycling primarily concerns designing and generating something new and innovative from discarded materials without destroying them. Both methods have advantages and can enhance sustainability in various businesses.

Upcycling

Upcycling has grown in popularity recently as the textile and fashion industry has come under severe scrutiny for its environmental impact. It transforms anything that would otherwise be abandoned or regarded unusable into something new and distinctive, frequently better than the original. As consumers become more conscious of their environmental impact, the demand for upcycled products will likely grow, making it a

Upcycling and recycling have emphasised the potential for reducing textile waste and environmental effects

significant trend to watch in the coming years. Upcycling can also be applied to other industries, such as furniture and home decor, where old materials can be repurposed into new and innovative designs. Designers may reduce waste and produce distinctive, one-of-a-kind pieces more sustainable than parent fashion goods by upcycling old or discarded materials.

Upcycling can be done with either pre- or post-consumer waste or a combination of both. Pre-consumer waste is generated during manufacturing (the leftover cloth after pattern cutting). Post-consumer refers to a finished product that has reached the end of its useful life for the consumer. The opportunities for upcycling are limitless and can lead to innovative and sustainable waste reduction solutions in different industries. Upcycling creates something new and better than old, used or disposed of items. The process requires environmental awareness, creativity, innovation and hard work. From this perspective, upcycling aims to develop products that are truly sustainable, affordable, innovative and creative¹.

Recycling

In the case of textiles, recycling can involve breaking down old clothing into fibres and using those fibres to create new textiles. It is an essential part of the sustainability movement and can be used to create new products from materials that would otherwise end up in landfills.

Textile recycling has become increasingly important in recent years due to new regulations in several countries. This process involves recovering fibre, yarn or fabric from pre-consumer and post-consumer waste and sorting it into five categories, i.e. second-hand clothing garments which can be repurposed, single-use garments, garments which can be recycled mechanically and chemically². Textiles can then be reused or mechanically/chemically recycled into new valuable products, including those made from recycled materials such as plastics. Textile reuse and recycling offer significant advantages over

incineration or landfilling. As more companies prioritise sustainability, one can expect a continued shift towards textile recycling in the textile and fashion industry and beyond.

Mechanical recycling

It is common to recycle textiles in which the fabric is broken down, but the fibres remain intact. This procedure is especially well-developed for cotton textiles. However, the protocols vary depending on the material. To avoid re-dyeing or bleaching of materials, the textiles must be segregated according to fabric composition and colour before starting the process^{3,4}. Once sorted, the textile materials are shredded, washed and separated into smaller fibres. These individual fibres are then spun through various stages, i.e. carding, drawing, etc along with other fibres, organic cotton or polyester, to maintain higher quality. Once the fibres are spun into new yarn, they can be used to produce creative textiles. This process functions as a semi-closed loop of recycling, where the number of times a material can be recycled depends on the fibre quality, which decreases with each cycle of mechanical processing.

Mechanical processing can also be used with materials other than textiles. In this case, recycled materials can be produced from polyethylene terephthalate (PET) plastic bottles. These are sorted by colour and type at recycling facilities, then shredded and washed to break them down and remove contaminants. The dried plastic remnants are moulded into PET pellets and then undergo extrusion to create new fibres, which can then be used to create new textiles.

Overall, mechanical recycling offers an effective solution to the problem of textile waste, reducing the amount of waste that ends up in landfills and reducing the need for virgin resources^{3,4}.

Chemical recycling

It is a process used on synthetic fibres that cannot be reused in their original form. Polyethylene terephthalate (PET) is one of the synthetic fibres that can be broken down using the process

of glycolysis, methanolysis, hydrolysis, and ammonolysis. This depolymerisation removes contaminants such as dyes and unwanted fibres, and the resulting material can be polymerised to create new textile products. Unlike mechanical recycling, chemical recycling produces high-quality fibres similar to the virgin fibre used and does not require new fibres to be made. Different chemicals and processes are used for other materials, such as nylon and cellulose-based fibres, but the overall structure of the process is the same^{3,4}. Companies like Eco Circle, Worn Again, Evrnu and Ioncell are researching and integrating chemical recycling into their production processes on a small scale.

Textile waste

Textile waste is generated in every step of textile manufacturing process. The global production of garments and their consumption has increased rapidly. The textile and fashion industry significantly contributes to the global waste problem and contributes to the growing amount of textile municipal solid waste. The Environmental Protection Agency (EPA) reported that in 2021 alone, 17 million tons of textile MSW (multiple solid wastes) were generated and 5% of all global landfills are being taken up by dumped textile waste². Some identified reasons for textile waste generation as: i) fast fashion; ii) lack of awareness about sustainability; iii) lack of knowledge about textile care and maintenance; iv) frequency of shopping; and v) lack of ecofriendly practices and quality materials.

The impact of the fashion and textile industry on the environment cannot be denied, with it being one of the biggest polluters in the world. Governments, NGOs and individuals are taking various initiatives to address the issue of textile waste. These include recycling and upcycling textile waste, promoting sustainable and ethical fashion practices, and reducing the overall consumption of clothing.

The materials used in textile recycling and upcycling can be

categorised into two main groups, pre-consumer waste and post-consumer waste. Both types of waste can be recycled/upcycled and turned into new, usable textiles, helping to reduce the fashion industry's environmental impact.

Pre-consumer waste

Pre-consumer textile waste is generated from secondary materials from the textile industries. These materials can be repurposed in other sectors such as furniture, mattresses, coarse yarn, home building, automotive, paper and apparel. Reusing these materials can reduce the amount of waste in landfills or incinerators. Pre-consumer waste can also refer to overstock or leftover garments that retailers have been unable to sell to consumers. These garments can be repurposed or used in other ways rather than being discarded.

Post-consumer waste

Conversely, post-consumer waste consists of textile garments and household articles discarded by their owners. These items are typically thrown away because they are damaged, worn out or outdated. Unfortunately, 85% of post-consumer waste ends up in landfills, contributing to the growing problem of textile waste². However, the remaining post-consumer waste can be directed towards second-hand retailers to be resold or passed on to warehouses dedicated to textile recycling. By doing so, the amount of waste in landfills can be reduced, and one can better use the resources.

Textile upcycling and recycling at the household level

Numerous recycling and upcycling activities are observed in the household that last a long time. Using old clothes for a newborn is a customary and traditional practice. These materials are cheap, easily accessible, free of surface treatments, and relatively soft. Earlier, it was seen that old sarees or

soft cotton were used as an alternative to sanitary napkins. Old clothing is typically used in households to mop and dust. The leftover or discarded cloth is often utilised as filler in cushions, beds, blankets and pillows. Many soft toys are made out of discarded fabrics. Converting old decorative fabrics into cushion covers or table mats is very common. In India and other countries worldwide, priceless traditional textiles are frequently given to the following generations as heirlooms and souvenirs.

Traditional textiles with the concept of upcycling

Crafts have been an integral part of human civilisation for centuries. Different crafts have evolved and passed down from generation to generation. There has been a growing interest in upcycling within traditional textile crafts in recent years. Many traditional textile crafts lend themselves well to upcycling, often involving working with fabrics and other materials that can be repurposed. Women mostly do these upcycled-based crafts. Many of these crafts have developed into livelihoods and sources of revenue generation. One of the oldest textile upcycling practices in the craft industry is frequently cited as the Bengali Kantha technique. In this craft, an old saree is used as a base material, engraving designs with running stitch hand embroidery. The Bakkarwal and Gujjar nomadic tribes, who live in Jammu & Kashmir and Rajasthan, respectively, use a variety of textile crafts based on upcycling as a part of their heritage and culture to conserve the ancient textile. Old woollen felt blankets are transformed into handcrafted carpets by the tribes of Jammu & Kashmir by incorporating needlework. Similarly, in Rajasthan, the tribal communities do patchwork, embroidery and mirror work to their existing old fabric to make bags, wall hangings, cushion covers, and mojaris (footwear). Chindi durries are made by weaving durries made out of old sarees, shawls and dupattas in a pit loom⁵.

Some traditional textile crafts that incorporate upcycling include applique, patchwork, quilting, khesh etc.

Applique

Applique work is one of the fascinating surface ornamentation techniques where small pieces of colourful cloth are cut into different shapes and sizes, and sewed in a base fabric to create various forms and patterns. This craft is traditionally practised in different parts of India. In this craft, the discarded fabrics are used to make different motifs which are further stitched in the base fabric to create a pattern.

Patchwork

Patchwork is a type of needlework where small pieces of coloured fabrics are stitched together to form a new fabric. Creating a patchwork is quite intricate, as it involves selecting and cutting small pieces of fabric and stitching them together to form a larger patterned fabric. Mostly the patchwork fabric has repeating geometrical patterns. In this craft, the leftover fabrics of different colours are stitched together to form a bigger fabric.

Quilting

Quilting is a popular technique that involves sewing two or more layers of fabric together to create a thicker, padded material. The layers typically include a top fabric, filler fabric and backing material. Quilting involves stitching the layers together using a needle and thread. Different types of hand embroidery are applied to bind the different layers of the fabrics. This craft is found in various parts of India using the same manufacturing concept with different aesthetic looks. In this technique, 3-4 old sarees are sometimes stitched together to produce quilts and old fabrics are primarily utilised as fillers.

Khesh

Khesh is a traditional weaving

technique that involves upcycling old or worn-out saris and transforming them into new textile materials. This craft involves hand weaving, where the warp is made of yarn, and the weft is made of narrow strips of fabric obtained by tearing old sarees. This technique has been used for generations in the rural areas of West Bengal and Bangladesh. Khesh fabrics can be used for various purposes, including clothing, accessories, home decor etc.

Awareness about recycling and upcycling

Researchers and scientists have emphasised the importance of recycling practises at an industrial level due to the awareness of sustainability and the need to save the environment.

Businesses collaborate with engineers, researchers and leaders in the industry to develop value-added products. Because nearly all textile waste is recyclable, they use old textiles and clothing instead of discarding them.

Panipat, also referred to as the capital of global textile recycling, is arguably one of India's most important, prosperous and historically significant industrial textile recycling hubs. Every year, this industry recycles about a billion ton of second-hand clothing (SHC) discarded by many developed countries. Low-quality products like blankets, shawls, carpets etc, are made using significant textile wastes, particularly SHC. Many carpet producers, suppliers of fibre and chemicals, recycling businesses and academic institutions actively pursue different strategies to recycle fibrous waste employing both mechanical and chemical procedures. Old denim is transformed into new products like bags and jackets, and discarded and old leather garments are repurposed to make new products. Recycling plastic bottles into polyester fibres has gained popularity in the textile industry. Fabrics made from these are used to make clothing and accessories. Recycling old textiles and clothing into new fabrics and materials is known as 'textile-to-

textile' recycling. The recovered virgin fibres are used to make new clothing without additional raw materials. Tyres thrown away can be recycled and used to make shoe soles. This process creates long-lasting, sustainable shoes while minimising the adverse environmental effects of tyre waste. Vintage and used clothing are also examples of upcycling. These items can be purchased or sold. It increases the durability of clothing and decreases the need for new manufacturing. Online marketplaces facilitate pre-owned clothing exchanges and sales.

Brands working on recycled and upcycled textiles

Indian brands

Many Indian brands and businesses have taken the initiative to make a sustainable approach toward the textile and fashion industry by recycling and upcycling. One of the biggest corporates in India, the Aditya Birla Group, specialises in producing polyester yarns. The creation of recycled polyester is one of their sustainable fashion endeavours. Post-consumer plastic bottle collection and processing yield recycled polyester, often known as rPET. Recycled polyester yarns can be used in various industries, including the textile industry. Using recycled polyester means fewer virgin polyester fibres, which are made from fossil fuels, are needed. Fashion companies and textile producers use recycled polyester yarn to make eco-friendly and durable materials. These materials can be used to make apparel, household fabrics and other products, giving the polyester fabric a competitive edge while fostering a circular economy⁶. Aditya Banger established the startup 'Trash to Treasure' to produce textiles from plastic garbage. Municipalities, trash pickers, and large corporates like Pepsi, Coca-Cola and Bisleri contribute their plastic waste, primarily PET plastic, to this collection programme.

All this garbage goes through the conversion process, turning it into fibres. The fibre is subsequently provided to its parent business to produce fabric for marketing⁷. Roshan Baid launched the Paragon Apparels Pvt Ltd brand Alcis Sports, which produces athletic apparel. The company is one of India's biggest manufacturers and exporters of sportswear and adheres to its core principle of sustainability. They collect plastic to produce a light and breathable fabric for sustainable sportswear in its ethical collection⁷. Nandan Bhat established the social venture EcoKaari and uses handloom and charkha to upcycle plastic to create artisanal fabrics. They collect plastic wrappers as raw materials and provide jobs for individuals. The organisation follows three pillars for sustainable development, i.e. communities, people, and the planet⁷. About 5.5 million PET bottles are converted daily by Polycycle, which recycles plastic into recycled polyester staple fibre without using a drop of water. The organisation manufactures dope-dyed fibres in more than 50 different colours. Additionally, solar and wind energy are utilised in every project. Consequently, it becomes an entirely ecofriendly choice. Its product line also comprises of polycycle antimicrobial fibre, dope-dyed polyester staple fibre and raw white polyester staple fibre⁷. RAW Pressery, a Mumbai-based firm, established RawCycle as a sustainable garment initiative. It began as a wellness and food and beverage startup. In 2019, the company created the RawCycle concept of recycling beverage bottles to produce t-shirts⁷. Shreeji Cotfab is a company that sells recycled yarn for weaving and knitting. The waste yarns are collected from textile factories in Vietnam, Indonesia and other Middle Eastern countries to make recycled yarn. The yarns produced are best suited for knitting.

International brands

The H&M Group is redesigning its products and implementing innovative

circular business models to increase the lifespan of goods and materials. H & M provides garment collecting services to clients in practically all of its stores to make the best possible use of the resources and energy contained in existing products. It delivers the collected materials to its partners after receiving them. The objects are then sorted and circulated by the following conditions:

- Reuse: Clothing that can be worn once more will be sold as used clothing.
- Repurpose: Old garments and textiles that cannot be sold again will be repurposed and made into other goods, including cleaning cloths.
- Recycle: All other products are recycled and turned into textile fibres, which are then utilised to produce insulating materials⁸.

Popular fast-fashion retailer Zara has tried to include recycled and sustainable clothing in its selection. Zara's 'Join Life' collection consists of clothing from recycled materials and ecofriendly textiles like organic cotton, recycled polyester, and Tencel Lyocell. The collection wants to make its products less harmful to the environment. As part of Zara's 'closing the loop' initiative, consumers can recycle their used clothing at Zara stores. Customers are urged by this campaign to participate in a circular economy and decrease textile waste. To introduce the 'Green to Wear' line, Zara partnered with the charitable Redress. This line of clothing includes items that have been recycled using textile scraps from Zara's production processes. Zara strives to utilise more sustainable packaging materials and less wasteful packaging overall and wants to make packaging more effective, use less plastic, and make packaging materials more recyclable. Some of Zara's stores now provide recycling facilities. Customers can recycle unwanted clothing at these facilities, promoting a more environmentally friendly disposal method⁹.

The luxury clothing company Gucci has implemented a recycling programme called 'Gucci Equilibrium'. This programme aims to advance

ethical behaviour inside the organisation and sustainability. Gucci recently launched circular lines of merchandise made from repurposed or recycled materials. Gucci-Up is a programme that enables clients to swap or sell their gently used Gucci items at specific Gucci boutiques. This initiative promotes recycling and extends the useful life of Gucci products. Customers can bring in their worn-out or broken Gucci things to be improved, reconditioned or mended, extending the useful life of the items. The Gucci Off the Grid line emphasises ecofriendly materials, and the collection intends to encourage a more circular strategy to fashion and reduce the brand's environmental effect. Gucci has taken steps to decrease packaging waste and improve the use of environmentally friendly products and has implemented packaging measures, including employing cardboard that has received FSC certification and reducing the usage of single-use plastics¹⁰.

Government policies

There are various government policies around the world aimed at promoting recycling and sustainability. In the US, the Environmental Protection Agency (EPA) has set a goal to increase textile recycling by 15% by 2030¹¹. In addition, the EPA has launched a National Recycling Strategy focusing on reducing textile waste¹². In Europe, the European Union has adopted a circular economy action plan that includes measures to promote sustainable fashion, such as using recycled textiles and reducing textile waste¹³. France has also passed legislation that requires fashion brands to recycle or reuse unsold clothing and prohibits the destruction of unsold goods¹⁴. In Asia, Japan has launched a 'Fashion Recycling Project' to promote the recycling of used clothing and textiles¹⁵.

In India, the government has launched a 'Green Protocol' that encourages sustainable practices in the fashion industry, including using eco-friendly materials and promoting recycling and upcycling¹⁶.

Overall, government policies are

essential in promoting sustainability and recycling in the textile and fashion industry. However, there is still much work to be done to address the issue of textile waste and promote a more sustainable and circular economy.

Conclusion

Research on upcycling and recycling in the textile and fashion industry has emphasised the potential for reducing textile waste and its related environmental effects. Reusing and recycling textiles lowers the garbage disposed of in landfills. One can increase their usefulness and reduce the demand for raw materials and new manufacture by upcycling or changing used clothing and textiles into new items like accessories, furniture and clothing.

The production of textiles is pollution-intensive. One can reduce the demand for new textile production and the resulting pollution from textile factories by recycling and upcycling. This covers the contaminating effects of chemical operations, dyeing procedures and waste disposal on the air, water, and land. Recycling and upcycling textiles can aid energy conservation by eliminating the need for energy-intensive procedures involved in producing new textiles. Energy-intensive processes like raw material extraction, shipping, processing and finishing are needed to create new textiles from virgin materials. One may reduce energy use throughout the production cycle by reusing and adapting existing fabrics. Recycling and upcycling align with the circular economy's guiding principles. The goal of a circular economy is to keep resources in use for as many years as possible through recycling, reusing and repurposing rather than following a linear model where items are used and discarded. This strategy encourages a more environmentally conscious and sustainable system and minimises dependency on limited resources.

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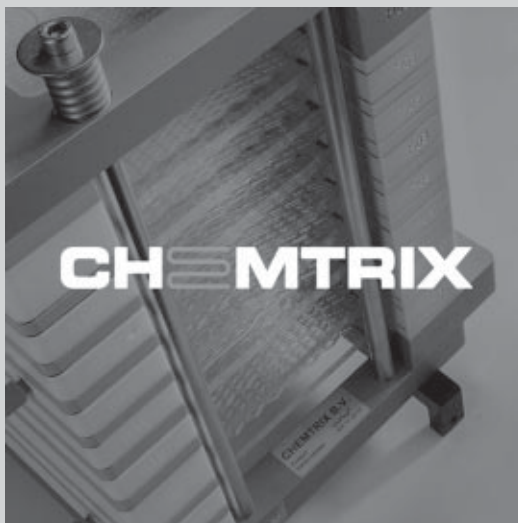
AGI Group acquires Chemtrix BV

AGI Group is excited to announce the successful acquisition of Chemtrix BV effective from 29th December 2023. Chemtrix, based in Netherlands, designs and manufactures a scalable portfolio of flow reactors that enables industry and academia to harness the advantages of flow chemistry and process intensification. This strategic acquisition will bring flow chemistry scale-up capabilities into the AGI Group, supporting both pilot and manufacturing solutions.

The AGI Group, founded in Japan, is a world-leading solutions provider for precision manufactured glass equipment across chemical processing industries in scientific sectors. The core strategy of the AGI Group is to expand its global presence to support customers and enable sales growth in markets outside of Japan.

The AGI Group's exciting and expanding portfolio of well-known brands includes the flagship AGI Glassplant brand; Premex Reactor, a supplier of premium quality, high pressure reactor systems and magnetic stirrers for research and development; and Syrris, the global leader in flow chemistry solutions for laboratory scale applications.

The Chemtrix flow reactor portfolio complements these offerings perfectly, and has been designed to change how



chemical processes are developed, delivering increased process safety, reduced operating costs and new chemical possibilities at scales ranging from milligrams in the lab through to tonnes for manufacturing.

Mike Hawes, CEO of AGI International, commented: 'We are very excited to have Chemtrix join AGI Group. We have a strong and successful history in providing high performance flow chemistry solutions for research laboratories. The addition of Chemtrix now allows us to support the market in scaling up their processes to the pilot plant and manufacturing scales. Chemtrix has a fantastic reputation in this market,

and we are delighted to be able to offer the high quality and high performance solutions in the Chemtrix portfolio.'

Dr Charlotte Wiles, CEO of Chemtrix, commented: 'Our strategy focusses on developing close collaborations with end users across academia, the fine chemicals and the speciality chemicals industries to develop a complete, easy to scale product portfolio whilst delivering our customers safe and reliable scale-up from the lab to industrial production. We are delighted to join AGI Group, and continue our shared mission of delivering high quality, efficient solutions that meet our customers' challenging process needs.'