Exploring traditional thread-making and simple weaving used in OPP lamination film upcycling for ecologically responsible textile craft

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Abstract. Aiming for sustainable eco-friendly craft/design practice, this design research explored upcycling-practice of OPP plastic waste using traditional technology to create an alternative raw material for textile craft. By combining cultural investigation into the textile-making tradition with Cradle-to-Cradle design principles, we identified the potential of traditional technology as an ecologically responsible production process. We also developed upcycling method to process OPP plastic waste material. This research resulted in: (1) thread-making techniques that produce different sizes of thread as raw materials and hand-woven textile, (2) revitalized endangered indigenous technology of craft-making that had been a part of human-nature ecology, (3) eco-design education that can be accepted by local textile craft community, and (4) textile craft products that express the local identity and promote environmental care.

1. Introduction

Plastic has been a worldwide environmental problem since its production; its use exploded after World War 2. Plastic waste management has not been successful in many countries in the world including Indonesia. According to a statistic in 2016, Indonesia generated about 65,200,000 tons of waste per year and about 85,000 tons of it is plastics. Plastic is widely used in industrial packaging from wet market to grocery store, toys, drinking cups, food packaging, bottled water, even in books and other products. Unfortunately, because 80% of the waste in Indonesia is thrown away unsorted; recycling practice at large scale is difficult to implement. This causes plastic waste to end up in landfills or leak into the ocean \cite{1}. Everyday habit of plastic use, general public ignorance, and lack of education in waste management at household level also poses a great threat to the wildlife and natural environment. As plastic generally do not biodegrade, plastics in landfills and oceans will continue to pollute for several generations ahead.

In the industrial sector, plastic is widely used in the production line of various products. Industrial printing is one of the waste producers that generally use common polymer such as OPP (Oriented Polypropylene) lamination film for the finishing process of book covers, packaging and others. Each of these process may produce an average waste of 1 to 20 cm width along 3,000 meters of OPP film. Because there had not been an attempt on recycling or upcycling OPP film waste, it keeps piling up.
With the abundance of OPP lamination film waste in Surakarta City, OPP waste treatment is urgently needed. Therefore, the authors came up with the idea of processing OPP film waste into raw material that can generate economic value.

Many companies face some difficulties in running their industrial waste treatment programs. To run waste management according to the established standards, companies need specific human resources, technology, and extra cost. Local printing companies in general are not prepared for this kind of extra demands. The scope of this research, therefore, is to identify OPP (Oriented Polypropylene) waste as a technical nutrient to create ‘nutrient’ for other creative, small-scale/home industries spread around the region. The waste treatment in this study was upcycling, which introduced by Cradle-to-Cradle (C2C) design principles with consideration to sustainable craft/design practice that promotes environmental soundness. The research presented more questions such as, what kind of upcycling process would be safe for the environment, yet practicable and beneficial for the creative and growing local industry? Is upcycling truly a new practice, or could we find it in traditional culture where a system has always been supporting the ecological health? Could we bring this dialogue of older ways of living and modern design discipline within upcycling practice? Then, once a renewable material is produced, how might we convince entrepreneurial parties concerning the production system and develop the product that could educate the market yet having social acceptability and a chance to create a circular economy? While responding to the initial issues of upcycling system, the research partly investigated indigenous knowledge system to find an approach to eco-effective waste management and production.

By combining cultural investigation on the local tradition of textile making with the C2C design principle of “waste equals food/resource”, this research identified the potential of traditional textile-making as an eco-friendly and low-cost production process as well as upcycling methods that will add the value to OPP plastic waste material. This finding facilitates the long-established production technology or traditional tools in craft making that the local people are familiar with to be re-introduced and re-designed for the upcycling process. With this process, the printing industry waste can become a valuable technical nutrient for other creative industries to thrive. The increasing awareness shown in the middle-class society concerning nature/environment conservation, social justice, and the effects of COVID-19 pandemic on economic growth could be the triggers we need for upcycling ideas to spring and proliferate.

1.1. The potential value of oriented polypropylene (OPP) lamination film waste
Made from Polypropylene resin and other synthetic chemicals, this plastic material is difficult to decompose naturally. However, OPP is the lightest plastic material that has excellent resistance to organic solvents and good heat and creep resistance. In addition to having write-on/wipe-off properties, OPP is a film that folds easily and highlights excellent optical properties (clarity). It is also economical, cost-effective, and softer than Polyester (PET) [2]. With its soft texture and a glasslike look, OPP film creates visual and tactile aesthetics that could be appealing when use as the materials in making certain products. From these properties, the authors recognized the potential of the OPP as a renewable craft-making material.

1.2. Adopting cradle-to-cradle (C2C) design principles for upcycling
Nowadays, as members of modern society, our activities could not be separated from industrialization. However, with the burgeoning reality of global destruction and gradual wildlife extinction that the nature is facing, designers as well as industrialists and policy makers need to reconsider their activity as well as their responsibilities as a human being and as a species among trillions other living beings on planet Earth. Thus, there is a necessity of implementing the right precept to praxis that will support environmental health, industrious activity and economic sustainability. For these reasons, the research adopted an approach of regenerative design developed in the 1990s by Prof. Dr. Michael Braungart, William McDonough and EPEA Hamburg. This method is called Cradle-to-Cradle (C2C) from which upcycling practice was introduced.
C2C design framework is inspired by the systems found in nature, aiming to not only reduce negative impacts on the natural environment, but also to leave a positive ecological footprint which results in safer processes, products, and businesses for healthier human and natural environments. ‘What is the entire system – cultural, commercial, or ecological – of which this made thing, and way of making things, will be a part of?’ [3]. C2C is aspired to influence and bring impact on design practice in both industry making and environment building that involve upcycling practice and eco-effectiveness mindset. ‘Form follows not just function but the evolution of the medium itself’ [3]. It is a catchphrase that encourages designers to reevaluate design thinking and resource use practice. It constantly reminds them about their position in the world, and whether their practices support both social and environmental needs or how policies and industrial systems should be designed on both small and large scales to be implemented with a certain effectiveness as a part of the ecosystem. How can designers help tackle the systematic failure fundamentally born out of design? This research addresses such imposing question, in a way that C2C design framework needs to be understood comprehensively, while being implemented transitionally starting from the smallest entrepreneurial niches. Either the upcycling process of the OPP waste, the new raw material it will produce, or the product development should be considered and designed with this synergetic precept in mind. In this research, OPP plastic waste becomes a technical nutrient for other products development. “A technical nutrient is a material or product that is designed to go back into the technical cycle, into the industrial metabolism from which it came from, isolating them from biological nutrients and allowing them to be upcycled rather than recycled – to retain their high quality in a closed-loop industrial cycle.” [3]. Upcycling is a process to upgrade a material’s value and enhance product quality for its second life and beyond, while simultaneously eliminating the need for virgin materials. When a product has passed its first service life, each of its part will not become useless waste, but can be thrown away to biodegrade and be a part of the natural nutrient cycle or alternately, they can be returned to industrial cycle as technical nutrient to supply for raw materials for new products perpetuating their service life.

Another factor of C2C mindset concerns the complexities of natural system that promotes biological, cultural, social and design diversity as well as resiliency brought by flexible systems. The fact that ‘universalized system of production erodes the diversity of cultural practice’ can be considered as a way to revive and/or re-adapt traditional technology for socio-cultural diversity and allowing potentials of regional culture to be recognized. Here, traditional technology as a part of indigenous knowledge system embodied in traditional thread-making and simple weaving mechanism is one of the declining cultural practices due to the lack of next artisan lineage and transmission of knowledge.

1.3. Indigenous knowledge system, traditional technology and upcycling practice

Indigenous knowledge system refers to ways of knowing and living mechanism that lead up to local wisdom that originally developed within a specific community to a certain geographical area [4]. This knowledge system entails collective understanding of the delicate interconnectedness of natural elements and the job description of human community within the ecosystem. Cultural ecology encompassing language, ritual, spirituality, social interaction, material culture, bodily techniques and resource use practice develops through interactions with the natural environment. As a biological organism capable of thinking, sensing and feeling, ‘human develops action and perception of the whole organic being (indissolubly mind and body) situated in a richly structured environment’ [5]. Humans are also capable to transform their interaction experience into a set of living skills such as agriculture and craft-and-tool-making.

Since native people highly depend on their natural environment, they need to manage their resources and use their activities to support sustainable ecosystem. In their ways of resource use practice, biological diversity needs to be maintained or even enhanced for their tangible and intangible forms of culture to take roots and flourish. Furthermore, waste management is a way to generate ecological services and in due course, creating their responsibilities ethos and aesthetic sensibility, enriching their material culture and tradition. Here we recognized in their way, waste coming out of resource use practices is repurposed and converted to become something of value, in other words, an older way of
upcycling practice. Szaky [6] suggests that upcycling practice has existed for thousands of years as an individual practice of converting waste or used objects into higher value/quality objects. As a case of upcycling in indigenous resource use practice is of giving new value to leftover thread waste. In the textile-making culture of the Balinese Aga people in Tenganan Pagringsingan village, naturally dyed warps and wefts with different motifs, leftover from Gringsing textile production, are being woven as wefts with plain warp to create another type of single-knot textile. This product is called Idap Panak (lit. life of the next generation). Such practice creatively adds an entirely new form of valuable textile artifact within their tradition while performing ecological services [7].

C2C design principles suggest that ‘human industry must protect and enrich ecosystems and nature's biological metabolism while also maintain a safe, productive technical metabolism’ [3]. It is similar to the indigenous approach in considering the relationship of human activity and its impact on environmental health and thus, waste management. Further classification of waste as those that can be directly thrown away to biodegrade and those that could become ‘food’ for other industries [3], paving a fundamental thinking for a more diversified forms of upcycling and extending service life of imperishable materials. In ways of upcycling inspired by tradition, existing technology and tools within local textile-making culture can be utilized to process the waste into a new form of product.

2. Research methodology and materials
This research was executed by first implementing the approach of C2C design principles and identifying the service life of the OPP film waste as technical nutrient for local textile and furniture industries. OPP film waste collected for this research came from one local printing Industry located in Surakarta City in different roll sizes. The assortment was performed based on color, texture, width, and thickness to create several variations of raw materials. Secondly, literature studies and field observation were conducted prior to COVID-19 pandemic to investigate local culture of craft making in Surakarta city and the neighboring regencies from which the traditional technology could be studied and re-introduced for upcycling system. This was done to map small-scale home industries that have the potential of implementing C2C design principles as well as the opportunity to introduce upcycled OPP as raw materials for creating high-quality textile crafts. Later, several local artisans of thread making and weaving in Klaten regency who still use traditional technology in their production system were identified within the community. They were guided to discover ways to process OPP waste into renewable and re-manufacturable material resources using traditional tools.

2.1. The upcycling process of OPP film waste into threads and woven textile
Today, a number of indigenous cultural practices in Indonesia is being marginalized or appropriated for consumerism, making it lose track of the long-established understanding of human-nature relationship. As the initial research took place, the focus of OPP waste as a ‘source of nutrient’ was implemented on small-scale textile and furniture home industry where production could be limited and quality-controlled for managing the practicality of C2C design principles while educating craft-makers regarding the potentials of the system. The focus of this is towards the upcycling system of imperishable materials and ecologically responsible production system inspired by indigenous knowledge system to bring awareness of the relationship between human-nature-industry.

Using these traditional tools (Figure 1-3), OPP film waste was processed in following manner:

a. Tools
   - Traditional thread-making tool ‘Erek’ used for processing OPP waste into thread variations
   - Traditional Lurik non-mechanical loom ‘ATBM’ used for weaving OPP thread into textile

b. Thread-making and weaving mechanism

2.2. Product development and mapping of service life
Three kinds of products yielded from this research are raw materials, textile crafts, and designed products resulted from combining materials experimented on upholstery and furniture.
Figure 1. Thread-making tools.

Figure 2. The making of OPP thread with traditional tools.

Figure 3. The making of OPP textile in non-mechanical loom (ATBM).

3. Research results and discussion
In Klaten regency, thread-making craft in Jombor area have existed for a long time along with the development of Lurik weaving in Pedan and Cawas areas. Although the craft production was originally
intended to meet the needs of Lurik (traditional cloth material) weaving centers, the craft later became an independent business, producing yarn and threads for other purposes. Thread making that utilizes leftover textiles from other regions is considered as unconscious upcycling practice, a potential of the region that could be enhanced. Here, thread-making technology which involves unraveling thread out of its previous interlace requires manual labor and traditional spinning tool (‘Erek’), where operation techniques, though relatively easy, requiring hands-on skills, time, diligence and a collective effort as method to achieve the desired quality. The process utilizes the space around the yard as well as public spaces in the neighborhood, making a worthy spectacle to behold. Production is carried out after dawn until before noon and is dependent on the weather. If it rains, all production will be stopped. Meanwhile, Klaten Lurik-weaving centers (Pedan and Cawas) are textile craft centers that have existed for quite a long time and cannot be separated from people's livelihoods that depend on the ecosystem [8]. The working network between Pedan-Cawas-Jombor in terms of yarn supply for Lurik craft has organically formed and create production ecosystem to date. Some lurik weaving units in the area still use non-mechanical loom because it has been passed down from generation to generation and become a tradition. All tools involved are handy, cheap and fixable by simple carpentry. In the weaving process, the possibility to use other traditional looms such as handloom, warp-weighted loom, back strap-loom or haute-lisse loom could encourage new inventions and adaptations by textile-making artisans within their community and diversify weaving practice as well as textile products while educating the importance of production system designed to be a part of a larger ecosystem.

Generally, all traditional craft-works are done at home or within the living vicinity, such as at the communal space within one neighborhood. This traditional thread-making and weaving chosen as means for upcycling is the same, in a way that may benefit environment, industrious entrepreneurs and society at large. Geographically, these two areas are the closest to the printing industry, thus a network of production could be supported by economically feasible distribution. Furthermore, when individual upcycling is done at craft production unit level, it could help maintain the waste management and keeps the decentralized system flexible until C2C awareness manifests into a cultural practice. Using the approach of C2C design principles, designers and artisans could start seeing their designs as a part of a larger ecological system that pay attention not only to the material needs of humankind but towards understanding the delicate natural systems, its health and interconnectedness.

Such mindset sees the life of humankind and other beings as integral unit. The design of OPP film waste upcycling process using the technology that the local people are familiar with is a wise innovation because; 1) it brings a positive impact on the environment and cultural diversity, 2) it will generate added value for the printing company concerned or anyone who can process it; 3) it produces alternative raw materials that will stimulate the creativity of craftsmen and enhance their craftsmanship.

![Figure 4. Simulation of product service life based on C2C circular design system.](image-url)
Designing is a meaning-driven practice to materialize intention. Product development of OPP film waste-yarns and textile should be designed with recycling/upcycling in mind. Future remanufacture and disassembly is based on biological/technical value where each part will be either goes to biodegrade or upcycled to become another product (Figure 4). The possibility of product development with small-scale home industry, for example furniture and upholstery, may involve educating the interested parties concerning the renewable material; where it is come from, what it could be, what values it contains and what next to do, paving a way for community services and creative eco-entrepreneurship. In this way, the authors hope to ignite the spirit of eco-production inspired by indigenous knowledge system and C2C principles, starting from identification of materials, socio-environmental needs, trend forecasting, and product storytelling to market penetration. This research also highlights the possibility of reviving extinct textile motifs (such as Lurik patterns and Songket motifs) or create an entirely new meaning-encoded motif using OPP wefts (Pakan). Meanwhile, decentralization of product development exercised in small scale and focused projects could spark the creativity for product diversity and introducing the ‘sustainable need-based, hand-crafted and limited’ concept to educate users concerning the products they buy. Another possibility is to encourage the home industry to advocate repair, reconstruction and remanufacture where the products that passed their usability can be brought back for upcycling to take place, further exploring creativity and ingenuity while extending the service life of each material used. At the moment, as long as the printing industry opted to waste OPP lamination film, supply of this material as ‘nutrient’ for textile-making industry can be sustained. However, the printing industry itself needs to be aware of this practice and encouraged to prepare for a synergistic interaction with the concerned stakeholders.

4. Conclusion
This design research produced an upcycling mechanism focused on low-cost, environmentally sound process with local familiarity and practicability that can be performed by anyone, individually and/or collaboratively. Traditional technology similar to upcycling have existed for thousands of years as a practice to convert waste or used object into higher valued objects. The idea of upcycling OPP film waste into valuable and eco-friendly materials have led to the experiments on the wisdom of traditional textile-making, using familiar tools and technology to produce yarns and high-quality textile craft that are ecologically responsible. The use of OPP threads as wefts to be woven and given new value in local textile-making culture is inspired from the century old of upcycling practices found in Tenganan Pagringsingsingan and the thread-making culture of Jombor respectively.

Thus, adapting tradition-inspired upcycling is one way that can be directed to develop the conventional design production system and aid local working units into design system and outcomes following C2C framework. The uniqueness of culture and traditional knowledge that is still preserved by thread-making craftsmen and Lurik weavers in Klaten regency supported this view and can be enhanced to create a narrative that can add another value for the upcycled OPP and production outcomes. In conclusion, introducing this production system as an alternative to upcycling practice and responsible artisanship may give a positive impact to the human-nature relationship, the environment, industry, and cultural diversity.

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