UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation into the Feasibility of Using the Red List of Materials

Timothy Chan

Yutian Zhou

University of British Columbia

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An Investigation into the Feasibility of Using the Red List of Materials

Instructor: Pat Cramond
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Name: Timothy Chan
Yutian Zhou

Abstract

The new Student Union Building (SUB) project at the University of British Columbia (UBC) is considering using the Red List of materials provided by the Cascadia Green Building Council's Living Building Challenge rating system. The Red List of material is a list of commonly found building materials and at various stages of their products lifecycle that are toxic to the environment or to the inhabitants of the buildings. Although the Council advises against using these chemicals and materials, alternative safer products for some of these materials are often difficult to replace or avoid than others. The objective of this project is to evaluate the feasibility of materials from the Red List via different approaches. Additional materials that are harmful to society, but are currently not included in the Red List are determined and explained in detail. Most of these materials found are related to polyvinyl chloride such as phthalates, a type of plasticizer used to give the rigid PVC its flexibility. Furthermore, heavy metals which are highly toxic in their elemental form are used as stabilizers in vinyl plastic materials. The potential problems and benefits of using the Red List for building construction are discussed along with the alternative options for Red List materials. Limiting the usage of these materials significantly lowers the risk of many chronic health disorders. However, because these materials are widely incorporated into building materials, replacing them is at the expense of cost and time. Finally, the Triple-Bottom-Line method is utilized for the comparison between Red List of materials and their substitutes. After the investigation of the Red List of Materials, the following statement can be obtained. The materials in the Red List are destructive in economical, environmental, and social aspects. However, these materials have extremely high performance for building construction, and only a limited amount of alternate options are available in the current market. As a result, whether the Red List of materials should be applied for the new SUB project is an issue involving time-cost and value trade off. The outcomes are either spending more time and money by employing less effective material for construction, or saving the money and time by applying the materials in the Red List. Since the new SUB project is based on sustainability, it is necessary to follow the Triple-Bottom-Line method and use more sustainable materials.

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List of Abbreviations

AMS	Alma Mater Society
CFC	chlorofluorocarbon
HCFC	hydrocholorfluotocarbon
HFR	halogenated flame retardants
LSZH	Low smoke zero halogen
PFC	perfluorochemical
PVC	polyvinyl chloride
SEEDS	UBC Sustainability Office's Social Ecological Economic Development Studies
SUB	Student Union Building
SVOC	Semi volatile organic compound
TPL	Triple bottom line
UBC	University of British Columbia
VOC	volatile organic compound

GLOSSARY

Feedstocks: something that is acted upon or used by or by human labor or industry, for use as a building material to create some product or structure.

Sick building syndrome: combination of ailments (a syndrome) associated with an individual's place of work (office building) or residence.

Plasticizers: additives that increase the plasticity or fluidity of the material to which they are added; these include plastics, cement, concrete, wallboard, and clay.

Dioxin (polychlorinated dibenzodioxins): a group of polyhalogenated compounds which are significant because they act as environmental pollutants. These organic compounds have been shown to bioaccumulate in humans and wildlife due to their lipophilic properties, and are known teratogens, mutagens, and suspected human carcinogens.

Polymerization: a process of reacting monomer molecules together in a chemical reaction to form three-dimensional networks or polymer chains. In polymer chemistry, there are many forms of polymerization and different systems exist to categorize them.

Injection molding is a manufacturing process for producing parts from both thermoplastic and thermosetting plastic materials. During the molding process, material is fed into a heated barrel, mixed, and forced into a mold cavity where it cools and hardens to the configuration of the mold cavity.

1.0 Introduction

In order to become of the global leaders in campus sustainability, UBC has developed many sustainability policies, programs, strategies, and initiatives in the past decade. The 2010 sustainability project supported by the UBC Sustainability Office's Social Ecological Economic Development Studies program conducts a triple-bottom-line comparison of materials, products, and technologies that are currently being used at UBC. According to the program overview, SEEDS is the first academic program in western Canada that combines the energy and enthusiasm of students, in intellectual capacity of faculty, and the commitment and expertise of staff to integrate sustainability on campus. Important fields of creating a sustainable campus with the aim of SEEDS include the building design, water and energy practices, food systems, climate change, waste management etc (USP).

The new SUB, one of the most significant operational projects at UBC, is currently entering the design phase and is scheduled to be completed in 2014. The student government, also known as Alma Mater Society, who is in charge of guiding the design and management of this project aims to transform the new SUB building into a symbol of sustainable design and responsible operation that will motivate future projects on campus and around the world. However, conventional solutions are not superior enough to achieve this ambitious goal. As a result, the AMS has requested the UBC student community to provide innovative and creative ideas that will advance the performance of the building (TNST).

The challenge of our section of the project is to investigate into the feasibility of the materials listed in the Red List that the new SUB project is considering to use. Since these materials are toxic to the society, we have to offer the project team with suggestions regarding about the application of the Red List in the construction of the new SUB building along with strategies for making the implementation of the Red List more practicable.

2.0 Background

The Red List of materials is a list of commonly used building materials that are either poisonous to the inhabitants of the buildings or dangerous to the environment. According to the Cascadia Green Building Council, this list serves as a tool for identifying and eliminating the worst in class chemicals and materials from the ecological health standpoint. The following is a summary of the materials recorded in the Red List, and building projects cannot contain any of the these listed materials or chemicals:

- Cadmium
- Chlorinated Polyethylene and Chlorosulfonated Polyethylene
- Choloroflourocarbons (CFCs)
- Chloroprene (Neoprene) – WITH THE EXCEPTION OF MEP EQUIPMENT
- Formaldehyde (Added)
- Halogenated Flame Retardants
- Hydrocholorfluorocarbons (HCFCs)
- Lead
- Mercury
- Petrochemical Fertilizers and Pesticides
- Phthalates
- Polyvinyl Chloride (PVC) – WITH THE EXCEPTION OF ROOFING AND PIPING
- Wood treatments containing Creosote, Arsenic or Pentachlorophenol
- Endangered Wood Species

3.0 Objectives

The object of this project is to evaluate the Red List using the following four approaches:

1. Determine additional materials that are harmful, but are currently not included in the Red List
2. Discuss potential problems and benefits of using the Red List for building construction
3. Identify alternative options for Red List materials
4. Applying Triple-Bottom-Line method for the comparison of materials

4.0 Investigation

4.1 Additional Materials not in the Red List

We have found many additional materials mainly related to addictives and treatments that should be present on the Red List but are not included currently. Additives and treatments are commonly used to enhance the properties of building materials such as water resistance. There are three main categories of compounds: volatile organic compounds, semi volatile organic compounds and heavy metals (HBN).

Volatile organic compounds are carbon compounds that vaporize at normal room temperature. It is seen that the toxic fumes are emitted at high levels at first but then taper off over time. Breathing the fumes overtime can lead to serious consequences. These types of chemicals can be used as feedstocks for some plastics, and also they are used in binders and other resins found in composite wood, insulation, paints, coatings, adhesives, and treatments. Their unique properties provide water resistance, enhance stain repellence, prevent fabric shrinkage, and improve crease resistance and fast color. Because of this, it is often difficult for companies to eliminate or reformulate products containing these compounds (HBN). Acetaldehyde, toluene, isocyanates, xylene, benzene are some of the VOCs not included in the Red List.

By not using VOCs, we can prevent short-term acute sick building syndrome and longer-term chronic health effects such as damage to the liver, kidney, nervous systems and increase of cancer risk. Formaldehyde included in the Red List is a known carcinogen; touluene is shown to increase the risk of having lung cancer; benzene increases the risk of having leukemia; and xylene is associated with non-hodgkin's lymphoma. Also, they are known to participate in atmospheric photochemical reactions, which lead to smog (HBN). Therefore, reducing VOCs usage results in cleaner air quality.

Semi volatile organic compounds are compounds with higher vapor pressure than VOC. They release gas more slowly but for a longer period of time. Also, they could be transferred to human by contact or ingestion through dust. They are similar to VOCs in that water resistance or stain repellence could be achieved through perfluorochemicals which is not included in the Red List. Phthalates are used to provide flexibility to the material and also inhibition of ignition or flame spread is achieved through the usage of halogenated flame retardants. Examples of where one can find phthalates are in vinyl flooring, upholstery, wall coverings, and shower curtains. For PFCs, they are found in carpets, upholstery, fabric and furniture (HBN).

Once again, the application of these compounds is distributed throughout building materials and limiting their usage is difficult. Also, the performance that they provide will be significantly reduced when alternatives are used. However their usage must be minimized due to a number of health risks. Phthalates are reproductive and developmental toxicants and have been linked to respiratory problems such as Rhinitis and asthma, obesity and insulin resistance[4]. PFCs which is a family of perfluorinated compounds is related to chlorofluorocarbons, listed on the Red List. They can be found in well known products such as Crypton, Teflon, Gore, Stainmaster and Scotchguard. Recently, they have been linked to cancer and developmental damage. More study is required to confirm whether they are carcinogenic (HBN).

Lastly, the third group of additives and treatments is the heavy metals family. They are metallic elements which are highly toxic in their elemental form or compounds. They are used as stabilizers in vinyl plastic materials and can be found in wire insulation, roofing, solder, radiation shielding, dyes, thermostats, switches, fluorescent lamps and exterior siding. Some of the heavy metals not included in the Red List are arsenic, antimony, chromium, copper, cobalt and zinc (HBN).

Because heavy metals release toxins during extraction, production, use and disposal, it is best to avoid using them. Also, their ability to bioaccumulate and enter the water system make them hazardous. Lead and mercury, included in the Red List, are potent neurotoxicants and cadium, which is also listed, is a carcinogen and can damage the kidney and lungs. Chromium, especially chromium IV is a carcinogen; antimony trioxide is a synergist in flame retardants and a known carcinogen (HBN).

4.2 Potential Issues with not using PVC

Because many of the Red List materials are related to polyvinyl chloride, it will be first discussed in detail. PVC is one of the major materials used in the building industry because it is cheap, durable and easily assembled; about 75% of the PVC is used for buildings. Its biological and chemical resistance makes it an excellent choice for piping applications. Moreover, it is used as wire insulators when combined with plasticizers. The chlorine content contains dioxins which are created during production and manufacturing process and also released during combustion. PVC contains some of the most potent carcinogens known, is a reproductive and developmental toxicant and can alter immune and endocrine systems. Because PVC is naturally rigid, plasticizers which are softeners are added such as phthalates. The effects of phthalates were discussed above. Heavy metals are also related to PVC in that they are used as stabilizers; their hazardous effects had also been described. Therefore, in order to eliminate the usage of many of these materials, alternatives for PVC must be found (Thornton).

Because PVC is used for numerous applications, it is extremely difficult to find alternatives. However, there has been success in using polyurethane for upholstery, non-chlorinated plastic recycled from auto safety glass for carpet backing and PVC-free interior flooring, wall and corner guards. Many other alternatives have been found and are listed in the Healthy Building database (Green Building).

The database covers products such as ceiling tiles, wall coverings, window treatments, furniture, electrical cables and piping. For each product, it lists the alternatives and also provides pros and cons for the suggested replacement materials. For convenience, it also provides the brands and the manufacturer's information such as telephone number, address and web links.

GREEN BUILDING: ALTERNATIVES TO POLYVINYL CHLORIDE (PVC) BUILDING MATERIALS FOR HEALTH CARE (PAGE 5 OF 11)

Products (CSI Division)	Manufacturer/ brand	Telephone #	Webpage	PVC-Free Brand products	Material	IAQ[1] Testing or Certification	HFR[2]-Free	PFC[3]-Free	Anti-microbial Free	Heavy Metal Free	Comments
Resilient Flooring (cont'd) (09 65 00)	Ceres Natural Flooring (a division of CBC (America) Corp.)	888.377.8801	www.ceresnaturalfloors.com	"PVC-Free" WELS sheet flooring	Polyurethane	Yes - CHPS	Complete information n/a as of 3/31/08	Complete information n/a as of 3/31/08	Complete information n/a as of 3/31/08	Yes	Sheet. Line being reformulated with expanded color options to be introduced in Summer 2008.
	Ceres Natural Flooring (a division of CBC (America) Corp.)	888.377.8801	www.ceresnaturalfloors.com	Sequoia "PVC-Free" Plank. Also named LifeLine LT.	Calcium carbonate (66%), thermoplastic polymer (2-propenoic acid, 2-methyl-, polymer with ethene, zinc salt, 31%), titanium dioxide and additional pigments (2%), with acrylic polymer ionomer wear layer (<1%)	Yes - CHPS	Yes	Yes	Yes	Yes	Plank. 60% post-industrial recycled content by weight. Manufactured by Upofloor in Finland.
	Forbo	800.842.7839	www.forboflooringna.com	Marmoleum	Natural linoleum	Yes - CHPS	Yes	Yes	Yes	Yes	Tile
	Mohawk	800.241.4494	www.themohawkgroup.com	StoneWalk	Limestone (80%), ethylene acrylic (20%)	Yes - FS	Complete information n/a as of 3/31/08	Complete information n/a as of 3/31/08	Complete information n/a as of 3/31/08	Complete information n/a as of 3/31/08	Tile. Manufactured by American Biltrite Canada, in Ontario. Also sold under name of "StoneScape." Contains 45% post-industrial recycled content.
	Mondo	800.361.3747	www.mondousa.com	Punti, Harmony, Geode, Natura, Terra Nova	Natural and/or virgin synthetic rubber	Yes - CA 01350	Yes	Yes	Yes	Yes	Roll and tile
	Nora	800.332.6672	www.norarubber.com	noraplan, norament	Rubber (natural and industrial)	Yes - GG, GGCS	Yes	Yes	Yes	Yes	Roll and tile. Most norament products contain 7% post-industrial recycled content. All noraplan products contain 10% natural renewable rubber.
	Nova	866.576.2458	www.novaflooring s.com		Natural linoleum	Yes - EU, FSC	Yes	Yes	Yes	Yes	Tile
	Tarkett	800.366.2689	www.tarkett-commercial.com	"Linoleum XF, Linosom Etfusco, Linosport, Toscano, Veneto"	Natural linoleum	Yes - CHPS and FS	Yes	Yes	Yes	Yes	Tile

Key: CA 01350 - California Department of Public Health Section 01350 Indoor Air Specifications; CAG - California Gold; CAP - California Platinum; CHPS - the Collaborative for High Performance Schools; EU - European tested, not tested in North America; FS - RFCI FloorScore; GG - Green Guard Indoor Air Quality; GGCS - Green Guard Children & Schools; GLP - CRI Green Label Plus; GS - Green Seal; IAG - SCS Indoor Advantage Gold; SCG - SCS Sustainable Choice Gold; SCP - SCS Sustainable Choice Platinum

* Health Care Without Harm and the Healthy Building Network do not endorse any of these products, have not tested them for safety or efficacy, and do not take responsibility for the accuracy of the information or product performance. Listing here is based solely on information provided by the manufacturer or otherwise in the public domain. This table is a work-in-progress. Kindly e-mail updates, suggestions, etc. to: products@healthybuilding.net

Figure 1: Example of the database (Green Building).

As one can observe, finding alternatives without having the database is difficult. Even with the table, one has to spend extra time to carefully pick out PVC building products and replace them with alternatives by contacting the manufacturers listed in the database. In addition, cost is an issue because most of the alternatives cost more than the cheap PVC. If the Red List is followed however, the chronic health effects discussed above could be significantly reduced.

In summary, a figure showing the environmental preference spectrum for plastics has been created. It shows alternatives for PVC such as polyethylene (non-chlorinated types), polypropylene, thermoplastic polyolefins and bioplastics. Although polyurethane is also an alternative, it is least preferable because it is made up of polyols and dilsocyanates. Dilsocyanates are severe bronchial irritants and asthmagens. Because polyurethane is made from hazardous chemicals such as formaldehyde and phosgene, it is environmentally non-friendly. Furthermore, they emit hydrogen cyanide and carbon monoxide during combustion which is extremely toxic (HBN).

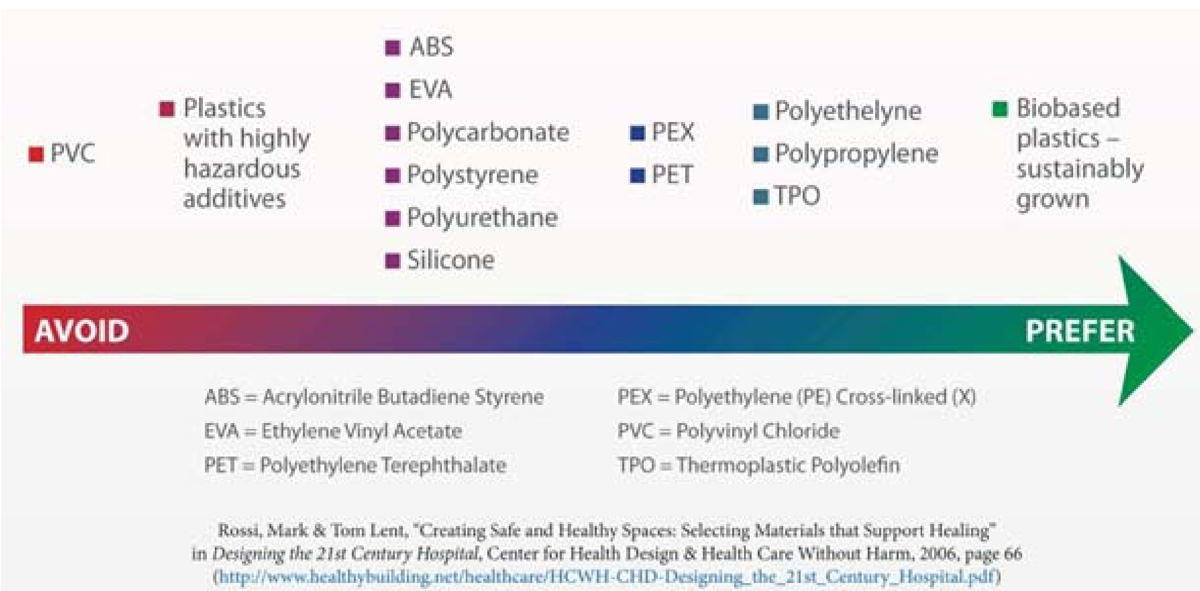

Figure 2: Environmental preference spectrum for plastics (Rossi, Mark & Tom Lent).

4.3 Alternative options

Semi volatile organic compounds

Phthalates can be eliminated by using non-PVC alternatives. Other toxic substances such as PFCs and HFRs could be reduced or removed by redesigning products to use less volatile compounds. Crypton Green is one of the successful examples of products aimed at reducing the usage of formaldehyde and PFCs (HBN).

Heavy Metal

It is often hard to identify all of the alternatives for heavy metals because they are widely incorporated into building materials. Currently, the best method is to remove these metals for the products; the Rohner Textile Company is one of the manufacturers who are still completive on the market selling heavy metal free products (HBN).

Endangered wood species

To prevent using endangered wood species, alternatives such as bamboo, palm wood, or pine beetle wood could be used. The material choice can be limited by the location. If the building project is located in North America, pine beetle wood should be used more because it is plentiful in that area. Transportation costs will be lowered and also carbon dioxide emissions will be reduced. However, if the project is located in an area with an abundant supply of bamboo, bamboo should be used more instead. The material choice can also depend on the application. For example, bamboo, a rapidly renewable resource, could be used for plank flooring instead of the endangered red oak because of its better resilience and water resistance. However, some bamboos use urea formaldehyde binders and the cost is comparable to hardwood floors. Cost is a factor in using alternative because they may cost the same if not more than the material being replaced (PVBMA).

4.4 Triple Bottom Line Evaluation

According to the project handout, traditional bottom line method in corporate decision making is determined only by financial costs and revenues; while triple bottom line refers to decision making process which takes into the consideration of social, environmental, and economic impacts in both positive and negative ways. In addition, the terms “social, environmental, and economic” were later replaced by three new terms, “people, planet, and profit” which succinctly describes the definition of triple bottom line and its goal of sustainability (Jensen & Liska, 2010).

“People” represents the human capital, pertains to fair and beneficial business practices toward labor and the community; "planet" represents the natural capital, refers to sustainable environmental practice; and "profit" represents the financial capital, is the economic value created by the organization after deducting the cost of all inputs.

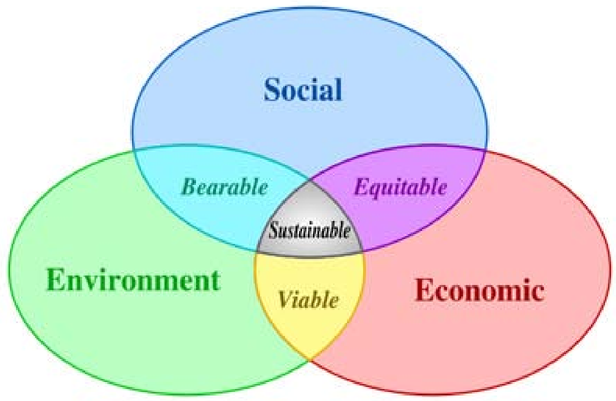

Figure 3: Three aspects of triple bottom line decision making process (GBS 2010).

As mentioned in the previous section, the alternatives for PVC are polyethylene, polypropylene and bioplastics. The triple bottom line method is used in this section to make comparison between these alternative materials for PVC.

Polyethylene

Polyethylene is a thermoplastic polymer consisting of long chains of monomer ethylene and is created through the polymerization of ethylene. It is considered to be the most widely used plastic in current market with an annual production amount of approximately 80 million metric tons. Methods utilized for the production of polyethylene includes radical polymerization, anionic addition polymerization, ion coordination polymerization or cationic addition polymerization. Even though, polyurethane is also an alternative for PVC, it contains certain amount of polyols and dilsocyanates. Dilsocyanates are severe bronchial irritants and is toxic and harmful for building contractors, workers, or users. Moreover, the extensive use of polyethylene generates important environmental issues. Since polyethylene is not considered biodegradable, the recycle process is very complicated (R. B. Fox, & K. Hatada, 2002). Thus, most of the commercial polyethylene ends up in landfills and in oceans. Economically speaking, polyurethane made plastic tubes are expensive materials to use for building construction. Based on research, the commercial PVC tube costs $0.4-0.5 per meter, while polyurethane tube costs $0.64 per meter.

Figure 4: Polyethylene foaming double-layer insulation tubes (PFDIT 2010).

Polypropylene

Polypropylene, same as polyethylene, is a specific type of thermoplastic polymer produced by chemical industry. It has a variety of applications include packaging, textiles, stationery, laboratory equipment, and plastic part for construction. There is a huge global market demand on polypropylene as the total production of polypropylene in 2007 is around 45.1 million tons worldwide. The most frequently used method of manufacturing polypropylene is melt processing which can be achieved through extrusion and shaping techniques. Common extrusion method is generating melt blown and spun bond fibers to form long rolls for future application; while the most common shaping techniques are injection and blow molding (Clive M., & Teresa C., 1998). Both the extrusion and molding processes are expensive when comparing to commercial PVC production process. The main function of polypropylene as an alternative to PVC is the insulation for electrical cables in low ventilation environment, such as underground tunnels. Polypropylene has an intermediate young's modulus and is normally tough and flexible, especially when copolymerized with ethylene (Polypropylene). This allows polypropylene to be used as an engineering plastic, competing with materials such as PVC. Environmentally speaking, polypropylene made cables are low smoke zero halogen (LSZH) cables and emits less smoke and toxic halogen which causes the generation of acid in high temperature circumstances.

Furthermore, polypropylene is easier to recycle, and has the number "5" as its resin identification code.

Bioplastics

Bioplastics, also known as organic plastics, are a form of plastics obtained from renewable biomass sources such as vegetable oil and starch; where as fossil fuel plastics are derived from petroleum. Since bioplastic technology is relative new, it is currently not cost competitive with fossil fuel plastics. Based on research, the global consumption of bioplastics is as high as 2 million tones in 2006. However, the total market size for bioplastics is difficult to estimate due the fragmentation of the current global market. Although most bioplastics are designed to be biodegradable, the bioplastics used for fuel line and plastic pipe are non-deposable. The goal in non-disposable applications of bioplastics is not biodegradability, but to create items from sustainable resources. The production and application of bioplastics in the field of construction is considered to be a more sustainable activity when compared with commercial PVC because it uses less carbon sources and produces fewer green houses emissions. As a result, bioplastics created a new era in building industry by significantly reducing the amount of hazardous wastes which can be stored as solid for thousands of years (Hong C., Peter H. F. Y., & Chee K. Ma., 1999-03).

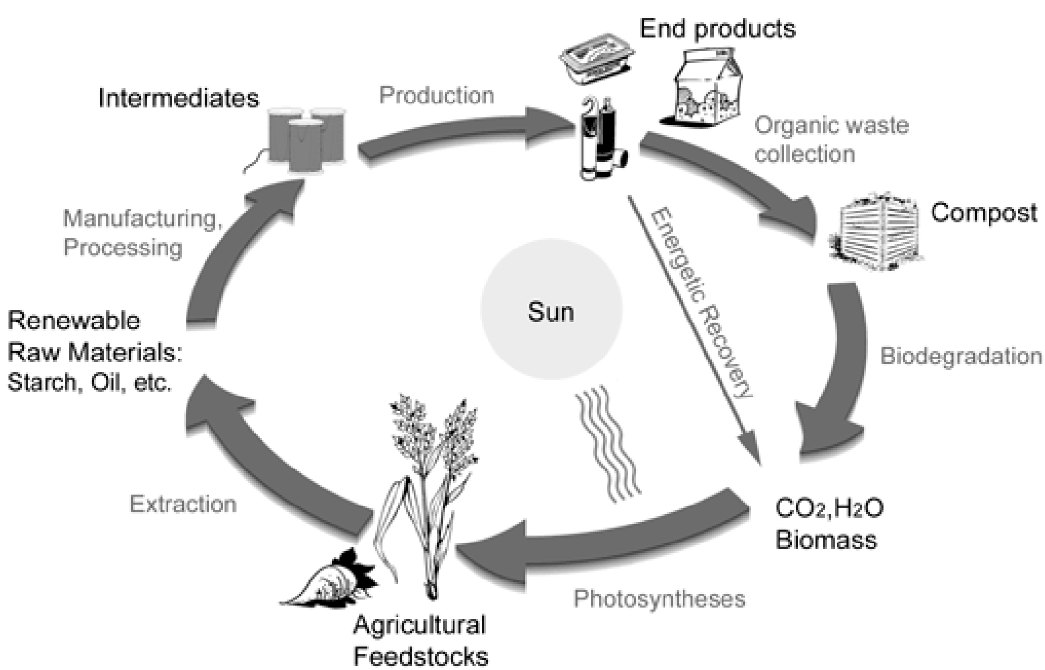

Figure5: Life cycle of bioplastics (VC, 2009).

5.0 Conclusion

Although the Red List of Materials provided by the Cascadia Green Building Council's Living Buidling Challenge rating system includes many commonly found toxic building materials, we have been able to find additional materials which are not included in the list. These chemicals are grouped in three categories: volatile organic compounds, semi volatile organic compounds, and heavy metals. Because they pose a serious threat to our health and the natural environment, alternatives have been found. Since many of these toxicants are associated to PVC, limiting the usage of PVC components can easily reduce their consumption as well.

In short, materials in the Red List are destructive in economical, environmental, and social aspects. However, these materials have extremely high performance for building construction and there are only limited alternatives available in current market. Although the Healthy Building database provides accessibility to the alternatives and their manufactures, it still involves a time-cost and value trade off. You either spend more time and money using less effective material for construction, or save the money and time using the materials in the Red List. Since our SUB project is based on sustainability, we should follow the triple bottom line method, and use more sustainable materials.

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