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An Investigation Into the Material Options for the Eco-Box Program

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ABSTRACT

The Eco-Box program is meant to be a sustainable alternative to using disposable food containers in the new SUB. Reusable containers are given out to students with food in them, and then returned to an AMS food outlet to be washed and reused. When choosing the material to be used for the containers, many different factors must be considered. Most importantly, the chosen material must be light-weight and non-breakable. This report compares three different types of materials, plastic, metal, and wood, which could potentially be used for the Eco-Box. First, a triple-bottom-line analysis is done on each material, evaluating the environmental, economical, and social impacts. These materials are then compared to each other to determine which would be the most appropriate to use.

From an environmental standpoint, wood would be the best material to use for the Eco-Box. It is the most environmentally friendly material of the three, as well as aesthetically pleasing, microwave and dishwasher safe, hygienic, and is light weight. However, wood is quite expensive when used as a food container. The second best option is plastic. It is the least environmentally friendly of the three materials, but it is the cheapest. Plastic is microwave and dishwasher safe, and has a watertight seal, but there are associated health risks with certain types of plastics.

The new SUB is aiming to be an environmentally conscious and sustainable building, focusing on renewable resources and low environmental impact products. Therefore, wood is the recommended material for the Eco-Box.

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GLOSSARY

Anti-corrosive: refers to the protection of metal surfaces from deterioration caused by oxidation or other chemical action.

Biodegradation: chemical breakdown as a result of microorganisms.

Carcinogen: a cancer causing substance.

Lacquer: a resinous wood sealer that gives a hard, glossy finish.

Non-Ferrous: alloys that do not contain an appreciable amount of iron.

Photosynthesis: a chemical process in which plants use the sun's energy and turn it into food and oxygen.

Residual: quantity left over at the end of a process.

Shellac: a sealer that is applied to wood, made from lac dissolved in ethanol.

LIST OF ABBREVIATIONS

AMS – Alma Mater Society

DEHP - Di-2-ethylhexyl phthalate

HDPE – High-density polyethylene

PET – Polyethylene terephthalate

PP - Polypropylene

PS - Polystyrene

PVC – Polyvinyl chloride

SEEDS – Social, Ecological, Economic, Development Studies

SUB – Student Union Building

UBC – University of British Columbia

1.0 INTRODUCTION

The following report is based on a food program called the Eco-Box program which will be implemented in the new Student Union Building (SUB) at the University of British Columbia (UBC). The Eco-Box program involves replacing the disposable containers used to package the food served by the Alma Mater Society (AMS) food outlets in the SUB, with reusable containers. The reason it's called the Eco-Box program is because these reusable containers are meant to be a more sustainable and environmentally friendly alternative to disposable containers. As recommended through personal meetings with Liska Richer, SEEDS Program Coordinator, Justin Ritchie, AMS Sustainability Coordinator, and Nancy Toogood, AMS Food and Beverage Manager, the purpose of this report is not to compare disposable containers to reusable containers but rather to compare the various options for the materials that can be used in the Eco-Box program.

The study has been refined to three popular materials: plastic, metal and wood. The reason these particular materials were chosen is because they are abundant, cheap, and non-fragile. These are the core specifications for materials that can be potentially used in the Eco-Box program. Materials such as silicon, glass, and ceramic for example, do not satisfy these requirements.

The following three sections will conduct a triple bottom line analysis on each of the three materials. A triple bottom line analysis considers three aspects: environmental, economic and social.

2.0 PLASTIC

There are seven main categories of plastics, all of which come from the same raw materials, petroleum and natural gas. The transport of materials to manufacturers requires a very large amount of fuel, as does transporting the finished products to the distributors and consumers. Plastic containers have a varying lifespan, depending on the type of plastic and how it is used. Plastic containers also have some negative health effects associated with them. There are many environmental, economical, and social aspects to consider when deciding to use a plastic reusable container.

2.1 ENVIRONMENTAL

There are seven main categories of plastics, see Table 1 (next page), each with slightly different characteristics and properties. Although the entire production process is not the same for each of the different types, they all come from the same raw materials. These raw materials, petroleum and natural gas, are refined into propylene, butane, ethylene, and methane. It is then heated and broken down into hydrocarbon monomers, smaller molecules. After this plastic resin is formed, the containers are made by injection molding and/or blow molding.

The most common types of plastic used for plastic reusable food containers are polypropylene (PP), number 5 in Table 1, and polystyrene (PS), number 6. The use of lead and cadmium in the production of these two types of plastics can be very harmful to the environment. During production, ethylene dichloride and vinyl chloride monomer are released into the air and water. These are toxic and carcinogenic chemicals which can be very harmful to humans and the environment. There are more environmentally friendly plastics, such as polyethylene terephthalate (PET), number 1, and high-density polyethylene (HDPE), number 2, which do not release the toxic chemicals during production.

Table 1: Plastic Recycling Codes

Plastic Identification Code	Type of plastic polymer	Properties	Common Packaging Applications
01 PET	Polyethylene Terephthalate (PET, PETE)	Clarity, strength, toughness, barrier to gas and moisture.	Soft drink, water and salad dressing bottles; peanut butter and jam jars
02 PE-HD	High Density Polyethylene (HDPE)	Stiffness, strength, toughness, resistance to moisture, permeability to gas	Milk, juice and water bottles; trash and retail bags.
03 PVC	Polyvinyl Chloride (V)	Versatility, clarity, ease of blending, strength, toughness	Juice bottles; cling films; PVC piping
04 PE-LD	Low Density Polyethylene (LDPE)	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Frozen food bags; squeezable bottles, e.g. honey, mustard; cling films; flexible container lids.
05 PP	Polypropylene (PP)	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture	Reusable microwaveable ware; kitchenware; yogurt containers; margarine tubs; microwaveable disposable take-away containers; disposable cups and plates.
06 PS	Polystyrene (PS)	Versatility, clarity, easily formed	Egg cartons; packing peanuts; "Styrofoam"; disposable cups, plates, trays and cutlery; disposable take-away containers;
07 O	Other (often polycarbonate or ABS)	Dependent on polymers or combination or polymers	Beverage bottles; baby milk bottles; electronic casing.

Source: gogreenwaterfilter.com/apps/blog/show/4473019-what-do-the-numbers-on-the-bottom-of-my-plastic-bottles-mean-

Another environmental impact of plastics is the transportation involved, during and after production.

This requires a large amount of energy as well as fuel for the transportation vehicle. This results in emissions of greenhouse gases and other pollutants. At the beginning of the production, the crude oil must first be sent to refineries. Once at the refineries, the necessary contents are extracted from the oil for plastic production. These raw materials are then transported to manufacturers to make the plastic. Once the plastic is made and formed into the desired shape, it is then transported from the manufacturers to the distributors, and then again to the consumers.

Once the plastic is produced, bought, and used, it then needs to be recycled. Not all plastics can be recycled however, and often it requires more energy to recycle old plastics than it does to make new ones. The plastics that are recycled are taken to plastics recycling facilities, intermediate processing facilities, or reclaimers where they are washed and ground down into small flakes of plastic. These flakes are then melted and formed into pellets, which are taken to product manufacturing plants where they can go through the production process again.

2.2 ECONOMICAL

The cost of purchasing plastic containers can range significantly, depending on the type, shape, what it’s made of, etc. Some containers are made of 100% recycled materials and are made in Canada or the USA, whereas others are designed in North America but sent to another country with cheaper labour to manufacture. The containers designed and produced in North America are significantly more expensive, however, they were not produced using any form of sweatshop labour. The fully recycled containers, as well as more environmentally friendly plastics such as such as PET and HDPE are also more expensive.

The expected lifetime of plastic lunch containers depends on a number of factors, including how often the container is washed and used. The lifetime guarantee from reusable container companies ranges anywhere from 2-10 years. The higher guarantees were for a typical household container, however, not a container being used in the SUB Eco-Box program, which would go through much more wear and tear.

2.3 SOCIAL

Reusable plastic food containers would be a suitable option for most students. They can be relatively lightweight, but also quite break-resistant. These are useful properties because most students will be carrying the containers around in their backpacks throughout the day. Another benefit of plastic containers is that they can be manufactured to have a water tight seal. This is extremely important because a lot of students have a laptop, cell phone, or other electronic devices in their backpack with the container which they may have rinsed out, and don't want the water to spill everywhere as it would damage the electronics. Plastics also have quite good insulating capabilities and are somewhat heat resistant. This is useful in the situation where hot food is placed in the container, and once the food is gone, the container doesn't stay hot and burn the students hands, like a glass or metal container would. Plastics insulating properties also helps to keep some of the heat in with the food, however, the containers are quite thin so this isn't as applicable in this situation.

There have been some studies that showed unhealthy side effects from storing, as well as microwaving, food in plastic containers. There are certain plastics, numbers 3, 6 and 7 from Table 1, which are known to be unhealthy to humans. Number 3 plastics, polyvinyl chloride (PVC), can leach traces of di-2-ethylhexyl phthalate (DEHP) into the food that it is touching. Number 6 plastics, polystyrene (PS), are made with benzene, butadine, and styrene. Benzene and DEHP are known to be human carcinogens. Number 7 plastics, polycarbonates, contain biphenyl-A, which is a synthetic estrogen and leaches into the food over time, as well as under heat.

Besides the health risks of being exposed to certain plastics, there are also esthetic issues. Plastic containers can get stained very easily, most commonly from tomato sauce or broth based soups. Although the plastics may be clean, they can hold these stains through many washes and make them look dirty and unpleasant. This may seem like a very superficial concern, however many students may be turned off the program from using unclean looking containers.

3.0 METAL

The main three metals which will be focused on are aluminum, stainless steel, and tin. Metals are quite environmentally friendly because they are completely recyclable and reusable. Metals are also strong, break-resistant, and light-weight when used as a food container. Although the metals focused on are relatively cheap, there are some associated health risks when using them as food containers.

3.1 ENVIRONMENTAL

Each of the three metals, tin, aluminum, and stainless steel, are recycled in a different way. Tin is the easiest and most efficient to recycle out of these metals. When tin is exposed to the environment, it will be naturally oxidized back to its original state. Due to this property, tin is essentially harmless to the environment and does not release any toxic or unwanted pollutants during its oxidation. Tin is also magnetic, allowing it to be easily separated from a pile of garbage, or other metals using a magnet.

In some cases there is pollution in the removal of tin residues. A shredding machine has been developed which is able to remove more than 98% of the pollutants and provide good quality scrap iron. Using recycled tin in the production of steel saves energy and can reduce the usage of natural gas by up to a ton each year.

Stainless steel can be recycled using a similar method, but currently only 60% of the steel can be recycled. It is usually composed of 25% recycled steel, 35% new steel, and 40% ferrochromium.

Aluminum is completely recyclable, however it requires much more energy than tin or stainless steel. If left on its own to oxidize, aluminum would take about 400 years. So, from an environmental standpoint, tin would be the best and aluminum would be the worst metal of the three to use.

3.2 ECONOMICAL

Tin is the cheapest metal to buy, at $0.97/lb, aluminum costs $1.05/lb, and stainless steel costs $1.65/lb. These prices are for scrap metal before being turned into food containers.

3.3 SOCIAL

Aluminum and tin are both very flexible metals. They are both anti-corrosive and easily machined, making them widely used as materials for soda cans and canned food. Stainless steel is anti-corrosive as well but is harder to machine than tin or aluminum and is also not as flexible.

Stainless steel is a much stronger metal than aluminum or tin, and all three are good heat conductors. Tin is often alloyed with other metals, such as steel or iron, to make it stronger.

Aluminum is often confused with tin and has replaced tin in most applications (e.g. tinfoil is actually aluminum). Both tin and aluminum are toxic to humans if ingested. Aluminum is considered to be one of the causes of Alzheimer's disease.

Metal containers are nonporous, allowing them to be cleaned easily. Most metal food containers, however, do not have a water-tight seal and are not microwaveable. This could pose as a problem for many students.

4.0 WOOD

The third type of material considered for the re-usable Eco-Box food containers was wood. Naturally, one would be inclined to believe that wood would not be an appropriate material for the Eco-Box program because it is an absorbent and porous material. Not only would this be undesirable to most users because of its inability to retain liquids, but it would also create a great deal of hygienic concerns. Furthermore, the cleaning and sanitizing of wood is said to be more difficult compared to other materials (Beyer). However, because these characteristics are very common amongst the different types of wood, most people don't realize that some types of wood do not share these characteristics, such as bamboo for example, which has an exterior waterproof film (Adams, 2003). The problem again with these types of wood is that if they contain cracks, they lose their water-repellant property because the inner material is absorbent and porous. Therefore the only real solution to this problem is to apply "finishes" to the wood. Finishes make the wood water-repellant, resistant to abrasion, acids and stains, more aesthetically pleasing, and finally they extend their lifetime (Knaebe, 1998). These qualities are of greatest interest when it comes to the reusable Eco-Box containers.

There are many types of finishes available for wood, and they can be applied to any type of wood. The type of wood which will be focused on however, is hard maple. The reasons for this decision are as follows:

1. Hard maple is hard and closely grained.
2. It polishes well.
3. It passes American and Canadian regulations for use in kitchen utensils such as bowls, rolling pins and chopsticks (Geyer, Gudbjornsdottir, 2002).
4. It is abundant in Canada and the United States.

The other types of wood which competed with hard maple were the hardwoods: cherry, beech and walnut, but hard maple was the best choice with respect to the reasons stated above, which were felt to be very important for a wooden reusable food container. The type of finish which will be focused on is a film-forming finish called lacquer. This is derived from the resin of a tree commonly known as the varnish tree. Most of the alternative finishes, such as shellac for example, use the same raw materials as plastic (discussed in section 2.0). These were disregarded in this section because they didn't derive from wood.

The following is a triple bottom line analysis on hard maple:

4.1 ENVIRONMENTAL

According to J. P. Moller's article "ScanWood", wood products are Eco friendly and have a zero carbon footprint because the carbon dioxide that is emitted in the manufacturing process of wood products is absorbed by trees. This doesn't take the whole picture into account though, because the process of cutting down trees for its wood disturbs the ecological balance. Trees moderate climate, stabilize soil, purify water and provide sanctuary for wildlife. The Eco-cycle of wood is shown in Figure 1 below.

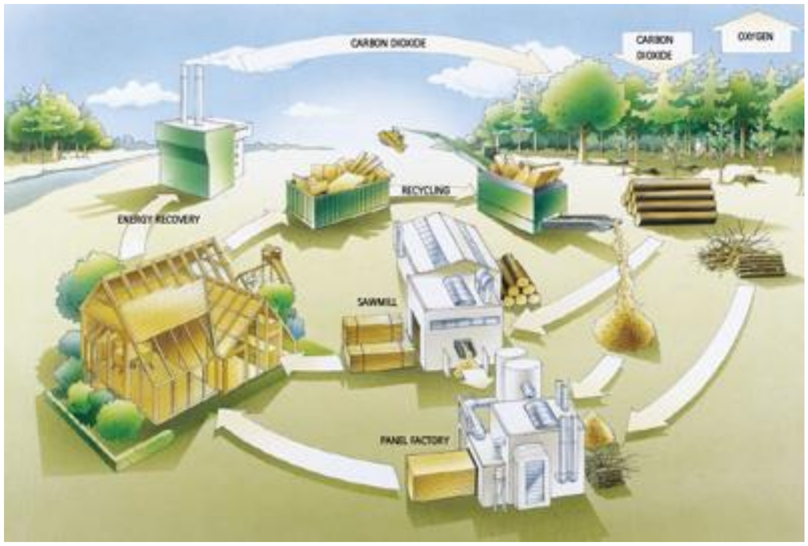

Figure 1: Eco-Cycle of Wood and Wood Based Products
Source: http://www.cwc.ca/DesignWithWood/Sustainability/Eco-Cycle?Language=FR

The following is a summary of the major stages displayed in Figure 1 above:

1. The trees are cut down and their wood is used.
2. After the wood products have been used, they are either reused, recycled or burnt for energy.
3. If the wood is burnt for energy it releases carbon dioxide.
4. Photosynthesis transforms solar energy into wood fibers in the growing trees, using water, nutrients and carbon dioxide. The sun is the driving force in this cycle.

What is true however is that in Canada, the manufacturing process for wood products requires the least amount of energy, and has the least impact on air and water quality. Canadian Sustainable Forest Practices have a reputation for being the best in the world which is quite comforting. Canada Wood and the Canadian Wood Council's solution to the ecological balance problem is to try to ensure that harvested sites are regenerated quickly.

Finally, the manufacturing process of wood products generates very little waste. Almost all by-products are used either as a raw material or as a source of energy.

4.2 ECONOMICAL

When it comes to the discussion of finite and infinite resources, it is known that wood is a renewable material, which means that it is technically an infinite resource, and therefore by using wood for the Eco-Box program, less finite resources will be used, which makes it a more sustainable alternative in terms of the use of natural resources.

As previously mentioned, because the wooden containers are dishwasher safe, less labour hours will be required in the cleaning of the containers process, which results in lower labour costs.

There is a significant difference between the price of wood as a raw material and the price of wooden containers as finished products. The reason for this is that wooden food containers are considered a luxury item and many of them are hand carved. Hard maple of one inch thickness costs approximately $6 per square foot, whereas $15 for a container manufactured from this volume would be considered cheap.

4.3 SOCIAL

According to the article "Wood in the Food Industry", wood has remarkably better properties concerning elimination of bacteria from the surface compared to plastic, but that metal was even better. Similar conclusions were also reached by tests conducted in Germany by the German Institute for Food Technology, and by the United States Department of Agriculture. G. Beyer concluded that the bacteria count on different types of wood was on average 15% lower than that on different types of plastics. This shows that wood is not, as commonly assumed, less hygienic than plastic.

The durability and beauty of wood make it an attractive material for the reusable Eco-Box containers.

This is at the cost of cutting down trees however, which are also aesthetically appealing because they create nice scenic views. This usually doesn't create too much concern because it's usually not the trees in residential areas and parks which are cut down. The finished wood is hard to dent and scratch resistant but because it's not flexible, the thinner the container is, the easier it will be to break by bending.

Wood is a microwave-safe material, which is an extremely important factor in the Eco-Box program because it makes the process of heating food easy and convenient for the user of the container, especially since there are many accessible microwaves in different locations on campus.

Hard maple is on average 45 pounds per cubic foot. To provide a rough estimate of the weight of a wooden container, a rectangular container of dimensions 0.8ft x 0.4ft x 0.25ft with a thickness of 0.015ft was assumed, and the weight of the finish was assumed to be negligible. This gives a volume of roughly (0.8x0.4x0.25 – 0.77x0.37x0.235) = 0.013 cubic foot of hard maple which weighs 0.585 pounds.

Finally, the finished wood is dishwasher safe which will make the jobs of the employees involved in cleaning the containers significantly easier but will also ensure that the containers are well sanitized.

5.0 COMPARISON OF MATERIALS

Now that a triple bottom line analysis has been conducted on each of the three materials, the best material for the Eco-Box program must be determined. In order to do this, a points-based system will be used. This will be achieved by producing a table with the different factors that were taken into consideration when assessing the materials, and then by awarding points to each material depending on its relative caliber in that category. It is important to note that this comparison focuses on the specific types of materials discussed in sections 2.0, 3.0 and 4.0 and not plastic, metal, or wood in general. Table 2 below shows the comparison table:

Table 2: Comparison of Materials

Factors	**Materials**		
	Plastic	Metal	Wood
Environmental			
Carbon Footprint	2	3	4
Recycling	3	4	5
Economic			
Natural Resources	2	3	5
Cost of Container	5	3	1
Social			
Hygiene	3	5	4
Insulating	4	2	4
Weight	5	3	4
Water Tight Seal	5	4	3
Total Points:	**29**	**27**	**30**

Points: 5 = Very good
4 = Good
3 = Mediocre
2 = Bad
1 = Very bad

5.1 COMPARISON FACTORS

The following is an explanation of each of the different factors that were considered, as well as the rating of each material in that category.

5.1.1 ENVIRONMENTAL

Carbon Footprint:

This factor assesses the relative amount of carbon dioxide produced in the manufacturing process of each material. Plastic produces the most carbon dioxide and wood produces the least.

Recycling:

This factor assesses the relative difficulty of recycling each material. Plastic is most difficult to recycle and wood is easiest to recycle.

5.1.2 ECONOMICAL

Natural Resources:

This factor assesses the availability of natural resources that must be used for each material. Wood is the best because it is a renewable resource. Plastic uses petroleum and natural gas, both of which are non-renewable. Metal uses natural gas which is non-renewable and metal ores which are renewable so it's better than plastic.

Cost of Container:

This factor assesses the cost of each type of container. Plastic containers are the cheapest and wood containers are the most expensive. Although wood is the easiest to collect, the manufacturing of wooden containers is more expensive than that of metal containers, which in turn is more expensive than that of plastic containers.

5.1.3 SOCIAL

Hygiene:

This factor assesses the hygienic concerns associated with the use of each material as a food container. Metal is the most hygienic and plastic is the least hygienic.

Insulating:

This factor assesses each material's insulating characteristics. Plastic and wood are both insulators, whereas metal is a conductor.

Weight:

This factor assesses the weight of each material. Plastic is the lightest and metal is the heaviest.

Water Tight Seal:

This factor assesses the relative difficulty of manufacturing a container with a water tight seal. Plastic is the best because it is easiest to shape and wood is the worst because it must be carved.

6.0 CONCLUSION

After extensive research and group discussions, the top material choices were narrowed to plastic, metal, and wood. More specific choices were then made for each type material. A triple bottom line analysis was then completed on these choices, highlighting the environmental, economic, and social impacts associated with the use of each material.

Based on the analysis conducted, the materials were compared on a number of different factors in each of the three aspects. Using a points-based system, it was realized that either plastic or wood would be suitable materials for the Eco-Box program in the new SUB at UBC. Wood and plastic are both light-weight and microwave and dishwasher safe, three important social factors for the Eco-Box. Wood and plastic differ significantly when it comes to environmental and economic aspects, however. In terms of cost, plastic would be a better option because plastic containers are significantly cheaper than wooden containers, but in terms of environmental concerns, wood would be the better option as it is more environmentally friendly.

Our personal recommendation is to use wood for the Eco-Box program, despite the fact that it costs more than both plastic and metal, because it will help UBC and the new SUB meet their sustainability goals.

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