

**Resilient Flooring: A Comparison of Vinyl, Linoleum and Cork**  
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**Application Parameters**

Floor coverings are found in most residential and commercial buildings. The coverings are not only valued for their aesthetic attributes, but also for the services they provide. Floors may need to be water-proof, or provide insulation or acoustical properties. People typically expect floor coverings to be attractive, comfortable, low-maintenance, durable and functional. Wood, carpets, ceramic tiles and vinyl are the most commonly used floor coverings in residential applications.

**Background.**

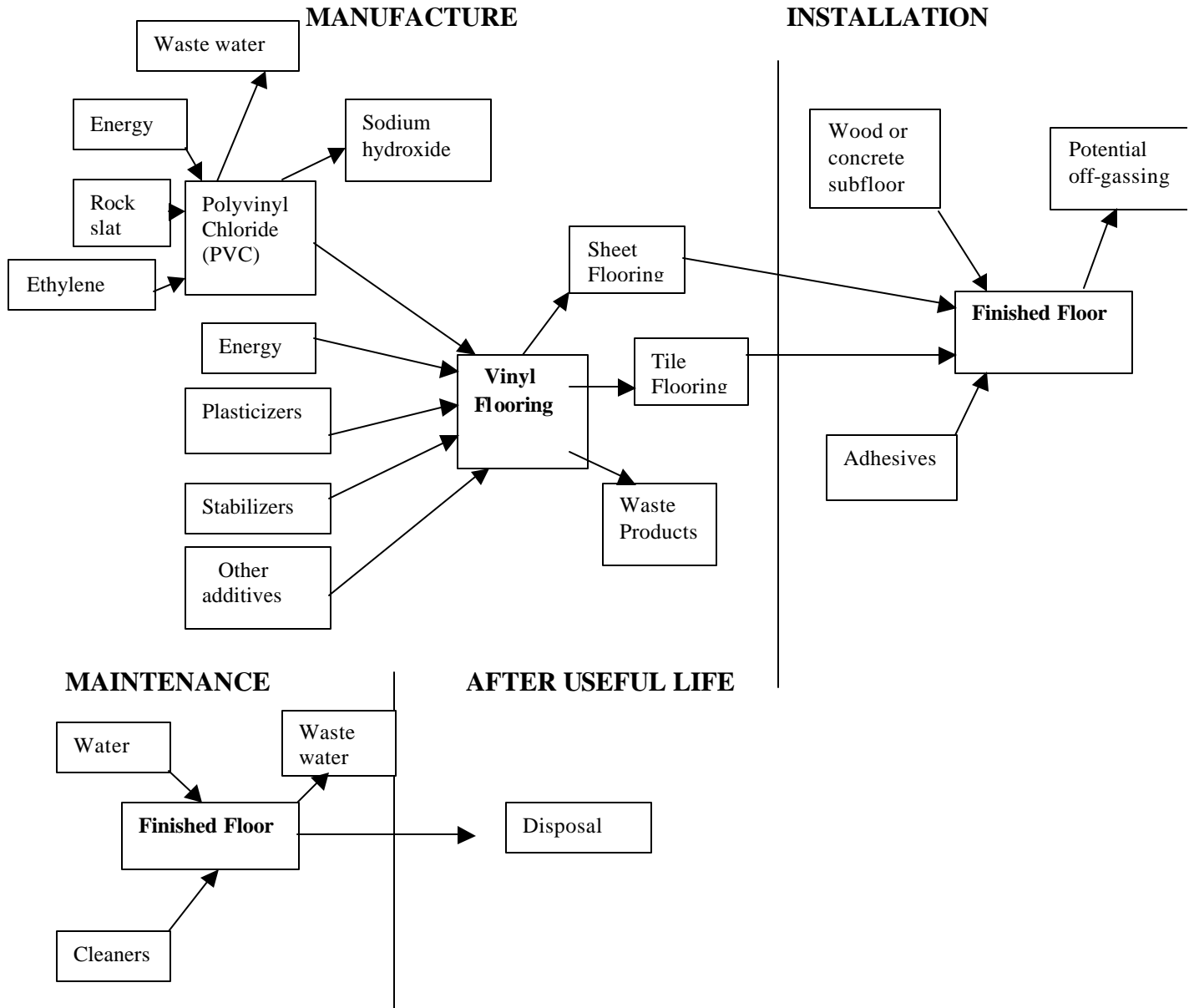
Floor coverings contribute to the solid waste stream because they are typically sent to land fills or incinerators at the end of their useful life. Also, many types of flooring, including most carpets and vinyl, are synthetic and require the use of petroleum-based chemicals and large quantities of energy to manufacture.

There are many flooring options available to consumers. For this materials comparison, the investigator chose to evaluate resilient flooring because of its wide use in residential settings, the availability of attractive, natural alternatives, and because of her interest in replacing the floors in her own kitchen and bathrooms.

**TRADITIONAL SOLUTION: VINYL**

Vinyl is an important solution in residential and commercial applications. A 1991 survey showed that vinyl is the flooring of choice for residential kitchens, with a market share of 73%, and for bathrooms (47%). Vinyl flooring is available in many low-end varieties, making it inexpensive when compared to other products used in similar applications. Available in sheet form or as tiles, it is not difficult to install. Unfortunately, this floor type may cause negative environmental impacts throughout its life-cycle (EBN 1994).

## Life Cycle Description



### *Production*

Vinyl flooring is manufactured by a process in which polyvinyl chloride (PVC) resin is combined with plasticizers and other additives and applied over a backing material. Plasticizers make vinyl sheet flooring flexible, and are not necessary in tiles. Stabilizers are added to prevent PVC from degrading due to heat or ultraviolet light. In the past, heavy metals such as lead and cadmium were used as stabilizers, but less toxic alternatives are now used. PVC is the most commonly used plastic in the construction industry, used for sewer pipes, flooring and wall coverings and weather stripping. PVC has been produced commercially since the 1930's (EBN 1994).

### *Installation*

Vinyl flooring is typically applied over a wooden subfloor with adhesives. The types of adhesives commonly used vary from those with high concentrations of volatile organic compounds (VOCs) to water-based, low-VOC alternatives. Indoor air quality is adversely affected by the offgassing of VOCs (EBN 1994). Some vinyl floors, particularly low-end varieties, may offgas. Plasticizers are often responsible for up to 50% of the VOC emissions from the flooring (excluding the adhesive), so vinyl tiles are better for indoor air quality than sheet vinyl because of the reduction of plasticizers (Hayes et.al. 1995).

### *Maintenance*

Vinyl flooring is a low-maintenance product, requiring periodic sweeping and mopping. The cleaners used for mopping range from water only to harsher chemicals, sometimes with disinfectants and VOCs.

### *Post-Useful Life*

Vinyl tiles are more recyclable than sheet vinyl because of the absence of plasticizers. However, the non-vinyl backings usually found on vinyl sheets and tiles make recycling difficult. Recycled vinyl flooring is available, but the source of the vinyl is usually from other products such as roofing film rather than vinyl flooring (EBN 1994).

### **System Components**

- Subfloor (usually a wood-based product)
- Adhesives
- Vinyl sheets or tiles

### **Adverse Impacts to the Natural or Human Environment**

The production of PVC used for this flooring solution requires petrochemicals and toxic chemicals. PVC itself is a carcinogen and worker exposure is carefully regulated to protect employees. Individual compounds in vinyl flooring typically do not have high VOC emissions, but off-gassing can occur depending on the particular combination of chemicals used. The choice of adhesives is important in reducing risks to occupants from off-gassing. Vinyl is seldom recycled and is more commonly land-filled, creating a rather large solid waste stream (EBN 1994).

### **Technological Performance Information**

Vinyl flooring is a low-maintenance, durable flooring solution with a long service life. It is available in many attractive colors and patterns and is often very inexpensive.

### **Cost and Availability**

Vinyl flooring is available at nearly every retailer that sells smooth, resilient floor coverings. The cost of vinyl tiles and sheet flooring varies widely, with many low-cost options available. The vinyl tiles with an adhesive backing purchased for this product comparison were \$0.99 per square foot.

### **Special Construction, Handling, Maintenance or Disposal Requirements**

None identified

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### **References**

Environmental Building News (EBN)(1994). Should We Phase Out PVC? 3(1).  
<http://www.ebuild.com/Archives/Features/PVC/PVC.html>

Hayes, S.M. Gobbell, R.V. and Ganick, N.R. (1995). *Indoor Air Quality: Solutions and Strategies*. McGraw Hill, New York, NY.

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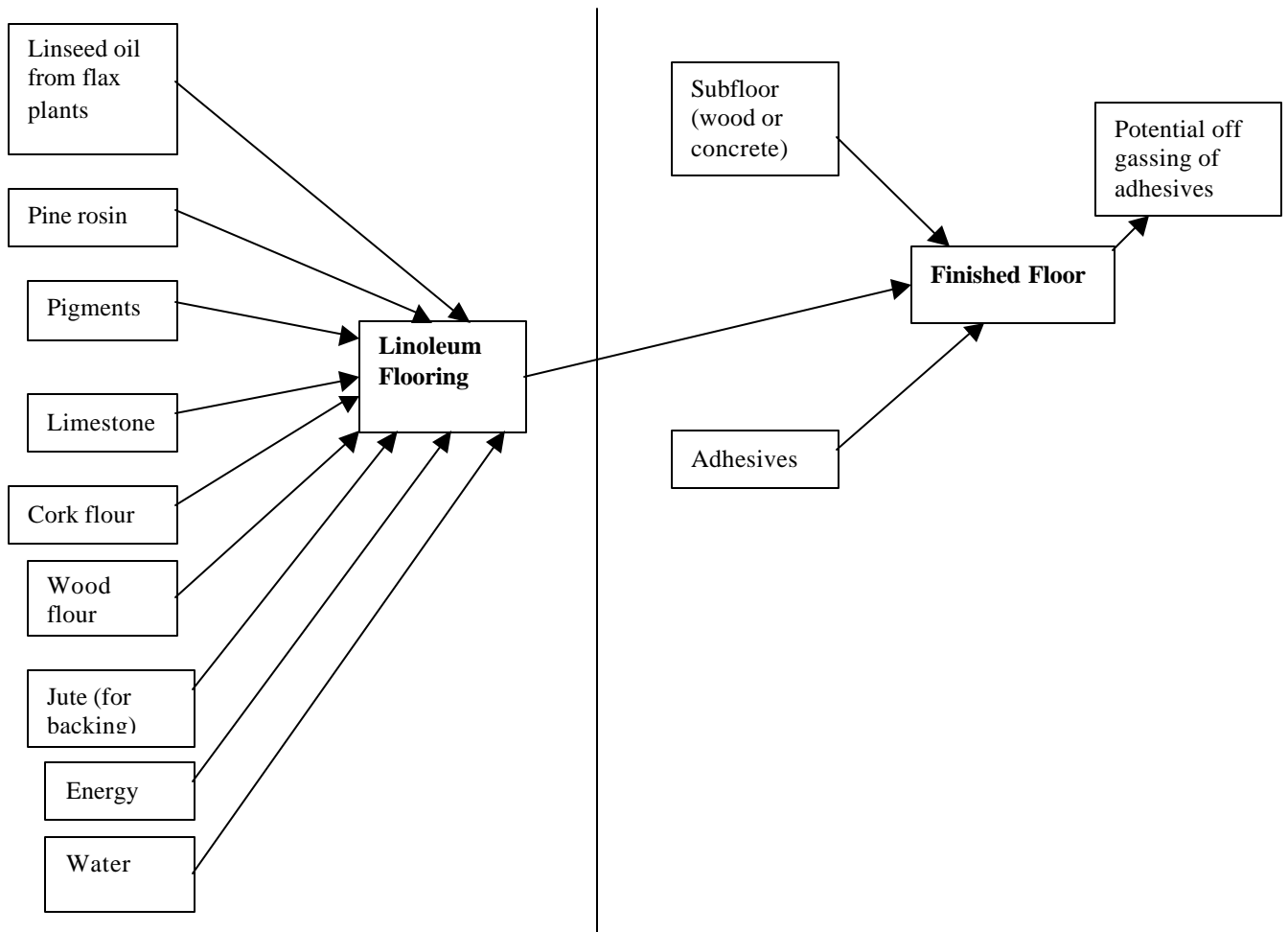
## GREEN ALTERNATIVE 1: LINOLEUM

Linoleum was developed in England in 1863 and it is still manufactured in Europe and imported into the United States. Once used extensively, linoleum was largely replaced by vinyl flooring because its colors tended to fade over time and controlling color consistency was difficult. Now, modern linoleum products retain their bright colors longer due to improved technologies, and linoleum is increasing in popularity (Philbin 1997).

### Life Cycle Description

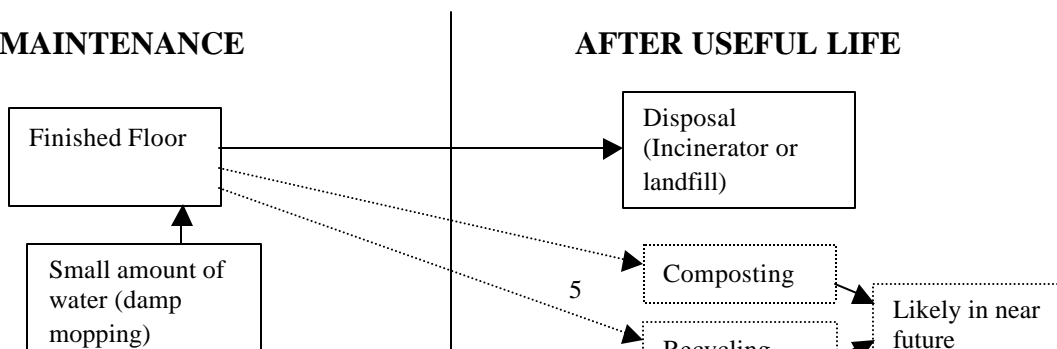
#### MANUFACTURE

#### INSTALLATION



#### MAINTENANCE

#### AFTER USEFUL LIFE



### *Manufacture*

Linoleum is made from all natural ingredients. Linseed oil is derived by pressing flaxseed and it is dried and ground into a powdery binder. This is combined with limestone, which is extremely abundant, pine rosin, and cork and wood flours to form a doughy material to which color is added. Once pressed, it is rolled onto a jute backing and dried. Jute is spun from fibers of jute plants grown in India and Bangladesh (Forbo Industries).

### *Installation*

Linoleum may be installed using a variety of adhesives. Solvent-free adhesives are recommended by Forbo, one manufacturer of linoleum.

### *Maintenance*

Linoleum floors are low-maintenance. Forbo recommends cleaning linoleum floors with a damp mop to reduce water use as well as minimize the “breeding grounds” for microbes.

### *Post-Useful Life*

Linoleum may be incinerated in a waste-to-energy facility yielding approximately 186 Mj/kg of heat. There are, however, few such plants in the United States. More often, linoleum is sent to landfills. While it is biodegradable, the length of time for degradation under anaerobic conditions in a landfill is likely rather long. Composting linoleum may be available in the near future, as tests for are currently at an advanced stage (Forbo Industries). Recycling may also be possible.

## **Description of System Components**

Like vinyl flooring, the system components include:

- a sub-floor, usually a wood product
- adhesive
- linoleum tiles.

## **Adverse Impacts to the Natural or Human Environment**

According to a life cycle study conducted by the J. Potting and K. Blok from the Department of Science, Technology, and Society at Utrecht University in 1993 (as quoted in Forbo product literature) that compared linoleum, vinyl, and wool and synthetic carpets, linoleum is superior when comparing environmental effects throughout the life cycle of these products, with the exception of fertilization effects. All of the materials used to produce linoleum flooring, including its backing, are natural and abundant resources. When incinerated, linoleum provides a source of energy without producing toxic emissions of its own. Some of Forbo’s linoleum products have been awarded the Netherlands Environmental Quality Mark. The parent company is ISO 14001 certified for its commitment to environmental management (Forbo Industries).

## Technological Performance Information

Linoleum is a low-maintenance, durable material that hardens as it ages with a service life of approximately 30-40 years. It is also available in a wide variety of colors and several patterns. Additionally, linoleum produces a natural bacteriacide that is not toxic to humans, making it an ideal choice for hospitals. Forbo claims that its Marmoleum® and Artoleum® products also possess naturally occurring anti-static properties. Linoleum is softer in feel and warmer on the skin than vinyl (Woolley et al 1997).

## Special Construction, Handling, Maintenance or Disposal Requirements

None identified.

## Cost and Availability

While the low-cost end market is still dominated by vinyl flooring, linoleum is making a come-back. Sometimes flooring sales people confuse the terms linoleum and vinyl, so you must be clear when asking for linoleum flooring. Linoleum is marketed more heavily to the commercial sector, but is available for residential applications. Forbo Inc. refers residential customers to Images Inc. in the Atlanta area for assistance.

The cost of linoleum is approximately \$4 –7 installed, comparable to vinyl. Linoleum is still manufactured in Europe, but imported to the United States by Domko Inc., Forbo Industries and D.L.W. Gerbert (Philbin 1997). Armstrong World Industries now has exclusive rights to market and sell D.L.W. linoleum. For more information, contact:

Forbo Industries  
Humboldt Industrial Park  
Maplewood Drive  
P.O. Box 667  
Hazleton, PA 18201  
800-842-7839

Armstrong Industries  
Bob Shannon  
P.O. Box 3511  
Lancaster, PA 17604  
717-397-0611

Gerbert Limited  
Andrew Dodge  
P.O. Box 4944  
Lancaster, PA 17604  
800-828-9461

[www.forbo-industries.com](http://www.forbo-industries.com)

Atlanta representative: Sean Hanrahan  
770-921-7953

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## References

Forbo Industries. Health and Environment :Marmoleum®, Artoleum® in the 21<sup>st</sup> Century. Product literature.

Philbin, T. (1997). "Linoleum Lasts". *Today's Homeowner*.

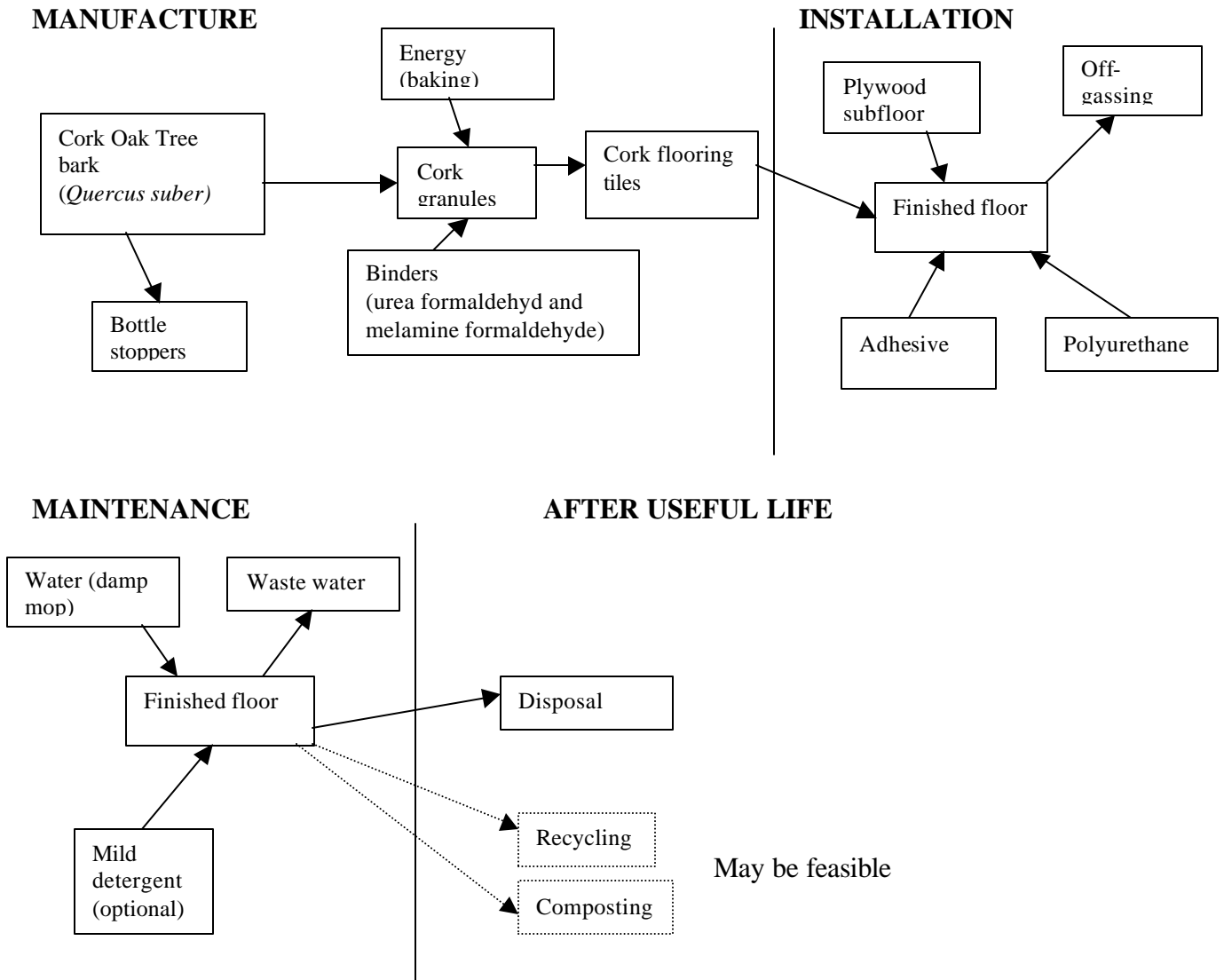
[Http://todayshomewoner.com/interior/1997/1110.digest1.html](http://todayshomewoner.com/interior/1997/1110.digest1.html)

Woolley, T., Kimmins, S., Harrison, P. and Harrison, R. (1997). *Green Building Handbook: A Guide to Building Product and Their Impact on the Environment*. T.J. International Ltd. Padstow, Great Britain.

## GREEN ALTERNATIVE 2: CORK

Used as a flooring material for over 100 years, cork is natural, durable, and fire-resistant. In both commercial and residential applications, cork is a beautiful, environmentally superior alternative to vinyl flooring.

### Life Cycle Description



### Manufacturing

Cork oak trees (*Quercus suber*) grow in savannah-like forests that cover approximately 5.4 million acres in seven countries including Portugal, where the majority of cork is harvested, Algeria, Spain, Morocco, France, Italy and Tunisia (EBN 1996). When a cork



oak tree is 25 years old, its bark is stripped for the first time. Every 9 years or so the cork is harvested from each tree using traditional hand labor methods. No more than 50% of the bark is ever removed, but the removal of the bark makes the trees more susceptible to disease. However, most cork oak trees survive many generations. Large slabs of cork are removed from the tree, cut up into strips and stored in the forest for 7 months or more to cure (Expanko.com 1999).

The best cork is used punched out to make bottle stoppers and the rest is ground into granules. These granules are combined with binders to form agglomerated blocks that are baked in molds. Various temperatures produce different colors of cork and dyes are never used for coloring. To produce floor tiles, the blocks of baked cork are cut into slabs, sanded and varnished. Tiles are hand-sorted by color (EBN 1996). Waste cork during manufacturing is usually burned to produce energy for the factories and is almost never sent to a landfill (Expanko.com 1999).

### *Installation*

Cork is applied onto a wooden subfloor that is free of cracks with a minimal thickness of 3/8" or over concrete using an adhesive. Most manufacturers suggest using a polyurethane adhesive that should not off-gas considerably after curing. Low VOC, water-based latex adhesives are also effective.

### *Post-Useful Life*

Cork is potentially recyclable.

### **Description of System Components**

Similar to the system components of both vinyl and linoleum, the system components for cork flooring include:

- Subfloor, crack-free wood or concrete
- Adhesive
- Cork tiles

### **Adverse Impacts to the Natural or Human Environment**

Cork flooring is relatively benign with respect to environmental impacts. No fertilizers or pesticides are used to promote tree growth or kill pests. Cork forests are managed carefully and most countries tightly regulate how often cork can be harvested. The binders used to agglomerate cork, however, may be toxic in spite of manufacturers' claim of using safe binders. One of the largest producers of cork flooring uses a urea formaldehyde and melamine formaldehyde mix as the binder. Polyethylene binders are used by another manufacturer. These binders may contribute to indoor air quality degradation. After cork floors are installed, a polyurethane coating is applied. The tiles can be purchased pre-coated with polyurethane or wax, but the floor is more susceptible to moisture seeping into the joints. Water-based polyurethane coatings may be specified,

but adequate ventilation is necessary during installation. Because the cork is produced outside the United States, transportation issues may be a concern (EBN 1996).

### **Technological Performance Information**

The properties that make cork such an attractive alternative resilient flooring solution is derived from its cellular structure of 14-sided, hollow cells. The cells are waterproof and airtight because of their strong and flexible cell walls that joined together in a honeycomb structure. Cork is compressible, strong, and insulating, acoustical and resistant to moisture damage. Cork flooring is susceptible to abrasion damage, but is otherwise very durable. In nature, the bark of the cork oak tree protects it from droughts and brush fires (EBN 1996).

### **Special Construction, Handling, Maintenance or Disposal Requirements**

None identified.

### **Cost and Availability**

Cork is a more expensive floor covering than vinyl or linoleum, with costs ranging from approximately \$1.50 to \$5.00 per square foot plus installation. The tiles acquired for the materials comparison display cost \$4.99 per square foot. Cork is not readily available in the United States. The following manufacturers make cork tiles available in North America:

Badger Cork  
26112 110<sup>th</sup> Street  
Trevor, WI 53179  
1-8000-255-2675

Korq, Inc  
400 East 56<sup>th</sup> Street  
New York, NY 10022

Bangor Cork  
P.O. Box 125  
PenArgyl, PA 18072  
610-863-9014

Floor Every Natural Cork  
865 Wall Street  
Winnipeg, Manitoba R3G 219 Canada  
204-256-7644

Dodge-Regupol, Inc.  
P.O. Box 989  
Lancaster, PA 17608  
800-322-1923

Ipocork, Ltd.  
586 Bogert Road  
River Edge, NJ 07661  
800-828-2675

AND

The company that donated samples for this project:

European Quality  
2905 Norman Avenue  
COQUITLAM B.C. V3C 4H8 Canada  
604-944-7294

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**References**

European Quality Cork Flooring product literature

Expanko.com (1999). Cork Floor Manufacturing. [Http://www.expanko.com/fl-man.html](http://www.expanko.com/fl-man.html).

Environmental Building News (1996). Products and Materials: Cork Flooring. 5(1) 10-12.

Woolley, T., Kimmins, S., Harrison, P. and Harrison, R. (1997). *Green Building Handbook: A Guide to Building Product and Their Impact on the Environment*. T.J. International Ltd. Padstow, Great Britain.

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## **Comparative Evaluation of Materials**

Based on the information collected for this study, linoleum flooring appears to be the most sustainable flooring choice when compared to vinyl and cork, with vinyl being the least sustainable. Table one shows a comparison of these three materials as scored by the investigator.

**Table 1. Comparison of Three Resilient Flooring Products**

This is in agreement with a comparison of environmental impacts printed in Woolley et. al (1997).

## **Summary and Conclusions**

For residential applications, both linoleum and cork offer natural and attractive alternatives to vinyl with its myriad of environmental impacts throughout its life cycle. However, other alternatives such as chlorine-free vinyl may also prove to be feasible choices for environmentally concerned buyers. The flooring industry currently offers a wide variety of floor coverings that are aesthetically pleasing, functional, and durable that reduce adverse environmental impacts.

## **Resources**

The Internet and the Georgia Tech Sustainable Facilities and Infrastructure library were the primary resources used in this materials comparison.