

## ENVIRONMENTAL IMPACTS OF PACKAGING IN THE U.S. AND MEXICO

Frank Ackerman, Tufts University

The rise in environmental consciousness in recent decades has included a focus on household waste. It is not the most urgent of the problems we face, but it may be the most immediately accessible. Global climate change, the destruction of the rain forests, and disasters such as Chernobyl and Bhopal are far away and hard for an individual to influence; but garbage disposal happens again and again, right at home under our personal control. Those who seek to act on their environmental concerns, therefore, often find it easiest to begin with the problems of solid waste. When a 1990 Gallup poll asked people in the United States what they had done in connection with environmental problems, 80% to 85% answered that they or their households had participated in various aspects of recycling; no other significant steps had been taken by a majority of respondents (Dunlap and Scarce, 1991, tables 44-46).

Packaging has come to symbolize the issue of waste. It represents roughly one-third of municipal waste in the United States, and only slightly less in Mexico. It has expanded rapidly in recent times; most adults today remember growing up in a world that used much less packaging. Perhaps most important of all, packaging feels wasteful: used once and then promptly discarded, it seems like only an ephemeral presence in our lives as it rushes from factory to landfill. Yet packaging remains ubiquitous; it is impossible to imagine an urban, industrial society functioning without it.

This paper presents a general perspective on the problems of packaging, examining both its real uses and the sense in which it could be considered environmentally harmful. It then discusses common views of the problems caused by packaging, and the results of two major empirical studies of the environmental effects of packaging, one in the U.S. and one in Mexico.

### MORE WASTE OR LESS?

The case against packaging, the sense that it creates growing amounts of needless waste, needs little elaboration. Less obvious is the counter-argument: packaging plays a crucial role in the distribution of goods, and may even reduce the total amount of waste in some cases. Packaging protects the integrity, cleanliness, and freshness of goods, allowing long-distance shipping while reducing waste and spoilage. For some new forms of packaging, designed to keep food fresh while in transit, the reduction in food waste may be much greater than the weight of the packaging (Alexander, 1993).

There appears to be an inverse relationship between the quantities of food waste and packaging waste, with richer countries generating more of the latter (Alter, 1988). Home preparation of fresh fruits and vegetables leads to discards of substantial volumes of shells, husks, leaves, stalks and other inedible portions (Careaga, 1993, pp. 6-7). If the same foods are commercially prepared and packaged, the inedible portions are removed at the processing plant, with potentially greater opportunity for composting or other environmental sound management of the residues. Of course, processed and packaged food is not as fresh, and may be less nutritious—but this is a different argument, separate from the quantity and management of waste.

The tradeoff between food waste and packaging waste explains one of the most remarkable empirical results in the field of "garbage research." Detailed surveys in the early 1980s found that households in Mexico City discard more waste than urban and suburban U.S. households, even after correcting for family size (Restrepo et al., 1991; for a summary in English see Rathje and Murphy, 1992, pp. 216-219). The Mexican households threw out twice as much food waste, while the Americans threw out more packaging and other materials; on balance the Mexicans discarded more per capita. Most other studies have found that the United States is the world leader in per capita waste disposal, and that developing countries generate much less waste.

However, the defense of packaging presented here only shows that some packaging is desirable, including some of the exotic new plastic and composite packages. It does not necessarily follow that all or most packaging found in the marketplace today plays a useful role. It is possible to believe both that some is essential, and that the trend is still toward increasing waste in packaging. Waste could result from a competitive "arms race" in which one company adopts larger, more elaborate packaging solely to compete with another company's larger, more elaborate packaging, in the struggle to win the attention of consumers. Producers could misinterpret consumer acceptance of increasing levels of packaging as evidence of a desire for even more. Cost calculations could show that it is cheaper to use more packaging, while failing to recognize the environmental costs of packaging production and disposal. Any of these reasons could lead to a pyramid of growing waste rising on a foundation of socially useful roles for packaging.

The sense of a trend toward increased packaging is significant, since individual retail packages are comparatively new in historical terms. Corporations large enough to establish nationally recognized brand names, and to mass produce and distribute packaged goods, only emerged toward the end of the nineteenth century. The technology of packaging took shape at about the same time: automated tin can production, paper cheap enough to use in bags and boxes, and the techniques for printing colorful labels all appeared in the late nineteenth century, while automated bottle production, aluminum foil, and the first plastic packaging (cellophane) date from the early years of the twentieth century (Strasser, 1989). Single-use (i.e., non-deposit) beverage containers were essentially unknown before World War II; the use of aluminum cans and plastic bottles, and the proliferation of plastics in general, only became widespread in the 1960s in the U.S. (Ackerman, 1997).

Recent studies suggest that the quantity of packaging is no longer growing faster than the output of goods in the United States. However, the slowdown is due to reduction in the weight of individual packages, not to reduction in the number of goods that are packaged. Meanwhile, countries such as Mexico can look forward to continuing rapid growth in packaging as U.S. brands and consumption patterns continue to spread.

Suppose, then, that we pursue the "environmental intuition" that (some) packaging is undesirable. What kind of a problem does packaging present? The question can be interpreted in two different ways. First, if packaging is bad for the environment, what kind of damage does it cause? Does it use up scarce landfill capacity, cause litter, use up scarce raw materials, or cause pollution in manufacturing or disposal? Second, is all packaging equally bad, or are there a few problem materials that are particularly important to avoid? Different, often inconsistent responses to these questions have been proposed by various recycling advocates and others concerned about waste.

But there is no need to debate these issues in the dark; it turns out that recent research allows surprisingly definite answers to be given to the questions about the problems of packaging. In brief, the obvious problems of landfill capacity and litter are less important than the pollution caused by manufacturing of packaging—and there is indeed one uniquely hazardous packaging production process, although not one that would be guessed without a knowledge of the chemistry involved.

### THE VANISHING LANDFILL CRISIS

Concern about waste and recycling is often connected to fears of a "landfill crisis"—that is, reducing packaging and other waste is said to be important because we are rapidly running out of disposal capacity. Discussion of the impending landfill crisis was common in the U.S. in the late 1980s and early 1990s. However, with a few years of hindsight, it is now clear that most places never came close to exhausting their available landfill capacity. In part the perception of crisis was due to a simple error, now widely recognized. Data on landfills is sparse, and many early accounts merely compared the numbers of landfills closing and opening each year, without considering their size. Since huge numbers of small landfills are closing, while small numbers of huge ones are opening, there have even been increases in disposal capacity in some areas. As in the initial panic surrounding the energy crisis of the 1970s, a serious long-run environmental problem was overshadowed by inaccurate predictions of immediate physical scarcity.

One of the most potent symbols of the landfill crisis was the legend of the Mobro 4000, the garbage barge from Long Island that was turned away from one port after another in 1987. At the time, the voyage of the Mobro was widely interpreted as evidence that there would soon be no place left to put our garbage. In fact, the Mobro's troubles were due to an unsuccessful deal between a Long Island Mafia boss (now in jail for conspiring to murder other trash haulers) and an inexperienced barge owner. The Mobro arrived in several southern states, and later in Caribbean ports, before signing firm agreements with any local landfills, leading to suspicion that it carried illegal or hazardous waste. Other garbage shipments to the same destinations, with signed disposal agreements in hand before they departed, continued during and after the Mobro's journey. (This revised history has appeared in several publications; for the definitively researched account, see Miller, 1996.)

There are some areas in the U.S. where landfill capacity will be a problem in the near future. Parts of the urban Northeast are, indeed, running out of space for waste disposal. New York City still enjoys relatively cheap waste disposal at its huge Fresh Kills landfill, said to be the world's largest; when Fresh Kills is filled and forced to close, in 10-20 years, the city will face a genuine crisis. Many smaller communities near New York City are already paying huge fees for long-distance shipping of their waste, or for incineration. Selected other areas also face problems; much of Florida, for instance, is geologically unsuited to land filling. But in most of the country, including most metropolitan areas outside the Northeast, disposal capacity remains relatively cheap and abundant. The same seems to be true even in the most urbanized parts of Mexico. Although Mexico City is one of the world's biggest and most crowded metropolitan areas, the Federal District appears to have ample waste disposal capacity in the huge (and seemingly expandable) Bordo Poniente landfill.

This is not an argument for complacency about land filling. Even in the absence of a short-run crisis, there may be other reasons for seeking to minimize the amount of land used for disposal, and the quantity of resources buried unproductively in the ground. Many people remain passionately opposed to siting new landfills in their communities; disposal capacity can become locally scarce in an area that refuses to build new facilities. Rather than bemoaning this NIMBY ("not in my back yard") syndrome, policy makers could take community opposition as evidence of the high implicit valuation placed on avoiding landfills. The higher that valuation, the more worthwhile it is to reduce and recycle the community's waste.

But while landfills are worth thinking about, they do not represent a crisis that demands immediate action in most of North America. The heart of the problem of packaging and waste must lie elsewhere.

### LITTER: MORE THAN MEETS THE EYE

Not all packaging, unfortunately, is properly discarded or recycled. Some of it ends up littered on streets, public spaces, and rural areas. Litter is hard to measure, and has rarely been studied systematically. It does, however, appear to be quite salient, and troubling to concerned citizens everywhere. Fast-food styrofoam, and aseptic packaging (drink boxes), two problem packages that are frequently cited as symbols of waste, are primarily problematical in terms of litter generation; there is no other sense in which they are associated with unusual levels of pollution, as we will see in the next section.

Litter has become politically controversial in the U.S. because of its association with single-use, nonreturnable beverage containers—a type of packaging which scarcely existed before 1960, but has now taken over the market. Ten states have enacted deposit/refund laws, or bottle bills, in part to reduce beverage container litter; industry groups such as the National Soft Drink Association have campaigned vigorously to prevent the adoption of any additional state or national deposit legislation. (See Ackerman et al., 1995, for details of this and other statements about litter, or Ackerman, 1997, for a summary analysis.)

The damage done by litter includes, most obviously, its ugliness. Many people go to great lengths and expense to visit parks and beaches that are litter-free, providing indirect evidence of the

importance of the aesthetic dimension of litter. But there are also more direct, physically damaging impacts of litter to consider. Broken glass, in particular, causes childhood injuries, flat tires, and perhaps damages to farm animals. The latter point is extremely controversial, with some farmers and farm organizations claiming that livestock have often been killed by ingesting broken glass in fields near public highways, while others insist that this virtually never happens. (Beyond the damages due to broken glass, any litter can cause health hazards if enough of it piles up in one place—a problem seen at times in neglected rural or low-income areas.)

While litter is a disturbingly visible problem in Mexico, the evolution of the single-use beverage container market is about 30 years behind the U.S.; nonreturnable beer and soft drink containers are just beginning to appear, as in the U.S. in the 1960s. The continuing mass acceptance of returnable bottles, and the existence of the network of local bottlers that distributes, recovers, and refills those bottles, makes beverage distribution possible with only minimal use of disposable packaging (the pattern in most of Europe as well). Once that system of support for refillables is lost, as in the U.S. today, it is almost impossible to rebuild it.

The problem of litter is more widespread than the (limited) reality of the landfill crisis. Litter does create real health and safety hazards when it involves broken glass, or when it piles up in an unsanitary manner. In addition to these physical impacts, litter has powerful visual or aesthetic effects on people; while little discussed in environmental theory, these effects remain an important part of perceptions of the environment in practice. But the effects of litter are not broad enough to support the whole weight of criticism of packaging. Litter is a very specific problem, and the potential remedies for it are likewise specific, albeit often difficult to implement. For a more comprehensive picture of the environmental impacts of packaging, it is necessary to turn to detailed empirical studies.

#### LIFE-CYCLE ANALYSIS I: PACKAGING IN THE UNITED STATES

By far the greatest environmental problems associated with packaging arise in the process of manufacturing it. Scarce resources are inevitably used— 150 billion beverage containers are sold annually in the U.S.—and a variety of toxic and otherwise damaging pollutants are emitted in the manufacturing process. These issues were central to a study of packaging impacts in the U.S., in which I was the principal investigator. We conducted a massive three-year comparison of the environmental impacts of all major packaging materials, sponsored by several state agencies, industry groups, and the Environmental Protection Agency. (The study is Tellus Institute, 1992; for brief summaries see Ackerman, 1993, or the policy-oriented discussion in Ackerman 1997.)

We set out to measure the externalities associated with packaging, that is, the costs imposed on society by packaging use that are not reflected in its market price. We examined glass, aluminum, steel, five types of paper, and six types of plastic, encompassing all the packaging materials in widespread use in the U.S. economy. For each material we compared air and water pollution from both manufacturing and waste management.

Our study was an example of life cycle analysis, a new mode of research that has flourished in recent years. The goal is to trace the environmental impacts of a product "from cradle to grave," that is, from production through disposal. However, it is increasingly evident that there is a limitation to life cycle analysis: the difficulty of interpreting the results. Studies of pollution impacts often have a mind-numbing quality. Long lists of emissions, with names that only an organic chemist could love (or remember), are matched with tiny numbers in exponential notation. While it is obviously not meaningful to add the weights of dissimilar emissions, it is not clear what else to do with the results of a lifecycle analysis.

While we delved into detail on more than 100 different emissions from packaging production and disposal, we also worked on developing a meaningful summary evaluation of those emissions. We weighted our emissions data by the relative health hazards of different pollutants, based on laboratory studies; this made a gram of dioxin, for example, millions of times as important as a gram of some other emissions. We then applied estimates of pollution control costs required under current regulations, as measures of the value society places on reducing emissions. The result was an implied

dollar value for the hazard caused by each pollutant, allowing easy comparison of different impacts. (As explained in the appendix to Ackerman, 1997, I no longer believe that these valuations can be used, as we originally hoped, as precise estimates of the economic cost of the damages caused by pollution. Nonetheless, they do provide a useful standard for comparison of packaging materials, yielding ordinal rankings that have proved robust under several recalculations.)

The study yielded four major conclusions, one expected and three unexpected. The result we expected was that, in every case where data were available for both virgin and recycled production of the same material, recycled production had lower environmental impacts. The magnitude of the environmental benefit from recycling differs widely by material. Aluminum recycling saves 95% of the energy required for virgin production, and eliminates the dirtiest, most difficult processing stages. In contrast, glass and paper recycling save only a little energy, and require many of the same processing stages as virgin production. Data on plastics recycling was not available at the time of the study; more recent information suggests that here, too, recycling reduces environmental impacts.

For products that can be made from only one material, this first conclusion might be all that one needs to know about environmental impacts. The conventional wisdom about recycling is confirmed: newspapers printed on recycled paper, for example, are better than ones printed on virgin paper. However, the conventional wisdom is more directly applicable to newspapers, which are always made of the same material, than to packaging. Choice among materials is the rule rather than the exception in packaging; most products can be packaged in more than one way, using more than one material. Our unexpected conclusions arose in the course of comparisons of the environmental impacts of different materials.

One of the unexpected results was the relative unimportance of pollution from the waste management process. Air and water emissions from new, state-of-the-art landfills and incinerators, and the emissions from collection trucks, are insignificant in comparison to manufacturing emissions. Often the waste management impacts were 1% or less of the production impacts for packaging materials. That is to say, as unattractive as it is to live next to even the newest, cleanest landfill, it might be 100 times as bad for your health to live next to a paper mill, oil refinery, or steel mill.

The second surprising result was the identity of the material that received the worst evaluation. Production of polyvinyl chloride (PVC), the plastic coded "3" on the bottom of packages, causes emissions of vinyl chloride monomer and other carcinogenic substances. Nothing else comes close to releasing as much toxicity per ton of packaging as PVC production. This result remains true even if proprietary emissions data supplied by PVC producers are substituted for the public EPA databases used throughout our study.

All plastics production involves manipulation and combination of complex organic compounds. But among the most common plastics, only PVC production creates and emits chlorinated organic chemicals. Here the packaging industry collides with another environmental controversy. The growing "toxics use reduction" movement has targeted chlorinated organics as a principal source of toxicity in industry.

More than a quarter of the chlorine used by U.S. industry goes into the production of PVC. Plastic pipe, widely used in plumbing today, is made from PVC, as is vinyl siding for houses. Other uses include numerous molded plastic consumer products, and the magnetic tape used in tape recordings. In packaging, PVC is used for water and oil bottles, snack packages, and the so-called "blister pack"—the combination of clear plastic front on cardboard backing that is often seen on drugstore and hardware items.

All of the packaging uses of PVC could immediately be replaced by other, chlorine-free plastics. The costs would be greater in some cases, but likely only by a small amount; after all, chlorine-free plastic packaging is already widespread, and does not impose an intolerable expense on the consumer goods that use it. A switch from PVC to other materials would be the most important step that could be taken to reduce the toxicity attributable to packaging.

The last major conclusion of our study was one of the most significant for public policy. When we compared per-ton impacts of packaging materials we found that, as we had expected, glass was best, followed by metals and paper, while plastics in general looked worst. But when we compared per-package impacts, we found that, PVC aside, the lightest-weight packages were almost always the best for the environment. To our initial surprise, (nonchlorinated) plastics came out quite well in many comparisons.

Before the fact, it seemed likely that environmentally oriented research might endorse the use of glass bottles for beverage delivery. After all, glass has a clean image. It is certainly recyclable, and its production uses less energy and emits less pollution than the production of other materials. If you are buying a ton of packaging material, it is true that you do less damage to the environment if you choose glass rather than any of its rivals.

The problem is, you are not buying a ton of packaging, you are buying a package. And glass bottles are heavy. Among single-serving juice containers, glass bottles weigh 10 to 12 times as much, per ounce of juice, as plastic bottles, aluminum cans, paper cartons, or drink boxes (all of which are somewhat similar in package weight per fluid ounce). So the question is, are the other materials 10 to 12 times as bad for the environment, per ton, as glass?

The answer is no. The other materials used to make juice containers are only two to six times as bad, per ton, as glass. On balance, therefore, the packaging impacts per ounce of juice are lower with any of the other materials than with single-use glass bottles. (Refillable glass bottles, which are no longer a significant part of U.S. packaging, have other benefits which may offset their weight; in effect, they have a low weight of glass per use.) Higher-impact materials allow the production of lighter-weight packages, and for single-use packaging it is generally package weight that turns out to be decisive. The lighter-weight packages are not always recyclable—but in the cases where a choice must be made between weight reduction and recyclability, reduced weight usually does more for the environment.

Similar patterns apply to a wide range of products and packages. Both styrofoam packaging used by fast-food restaurants and aseptic packaging (drink boxes), often cited as symbols of waste, are very light-weight, and have production impacts equal to or lower than alternatives, per unit of delivered contents. The identification of these two packages as uniquely problematical must be either a mistake based on lack of information, or a statement about the importance of litter—the one area where the impact of styrofoam and drink boxes is unmistakably visible.

## LIFECYCLE ANALYSIS II: PACKAGING IN MEXICO

In 1993-94 I had the opportunity to participate in a similar (though not completely parallel) study of packaging in Mexico, sponsored by the U.N. Industrial Development Organization with support from Mexican and U.S. businesses. (For the full report on the project see Instituto Internacional del Reciclaje, 1995; for a shorter report in English on many of the issues discussed here, see Ackerman et al., 1994.) Much of the project was spent attempting to create data on packaging production processes and emissions in Mexico, an effort which was only partially successful. To an even greater extent than in the U.S., understanding of environmental impacts in Mexico requires continuing expansion of data collection.

To the extent that the available data permitted, we attempted to evaluate the environmental impacts of Mexican packaging, using an updated version of the methodology from the U.S. study described above. PVC appeared to be the most hazardous packaging material produced in Mexico as well; emissions of vinyl chloride, the key carcinogen released in PVC manufacturing, were noticeably higher in Mexican than in U.S. production.

For other packaging materials, production of the same material was generally 1.5 to 3 times as dirty in Mexico as in the U.S. In large part this was because Mexican industry used electricity from power plants in Mexico, which were much dirtier per kilowatt-hour than their counterparts in the U.S.; lifecycle analysis typically attributes the appropriate shares of power plant pollution to each production process. Thus cleaning up Mexico's electric utilities would be one of the top priorities for reducing packaging production-related emissions.

The tentativeness of the analysis, and the limitations of Mexican data, have led to criticism of the study. An unusual argument, heard at times among life cycle analysis practitioners in the U.S., has been raised concerning the Mexican study: since both the data and the analytical methodologies are imperfect and will continue to evolve, it is suggested that no evaluations of packaging materials should be made, and no conclusions should be drawn, on the basis of existing research. This suggestion, if adopted, would send life cycle analysis down a path that no other science has followed.

On a more typical path, discussion of current conclusions based on existing research is the indispensable starting point for further progress. While it is encouraging that life cycle analysis practitioners have begun to discuss adoption of standard methodologies, the progress of this discussion appears glacial in pace, and may be decades away from completion. Meanwhile, it is surely worthwhile to tell the world that, on the basis of research to date, polystyrene (styrofoam) is a less serious environmental problem, and PVC a more serious one, than most environmentalists believed five to ten years ago.

An additional issue in Mexico, which has no contemporary analogue in the U.S., is that traditional recycling of packaging by scavengers (*pepenadores*), who work and often live on landfills, poses serious health hazards to the people involved. The problem is directly linked to packaging; most of the materials that are worth scavenging from urban trash today are packages. The practice of landfill scavenging, common in developing countries today (and in the U.S. in the nineteenth century; see Melosi, 1981, or Rathje and Murphy 1992), is one of the worst aspects of the waste management process from either a humanitarian or environmentalist perspective.

Moreover, scavenging is not even, in Mexico, very efficient at recovering all the recyclable materials in the waste stream. Data collected for the project on waste management in Mexico City implied that scavenging recovery rates were lower than those achievable through modest formal recycling programs. However, landfill scavenging would remain a public health disaster and an affront to human dignity even if it were efficient at material recovery.

The desirable solution to the problem, converting the landfill scavengers to employees of a formal recycling program, is both expensive and politically difficult to enact. To date such a conversion has been carried out only in Ciudad Juarez and in the Federal District. Much more of the same needs to be done throughout the country. Although our study offered no formal analysis leading to this conclusion, it appears that the problems of the *pepenadores* are the most urgent impacts of packaging waste in Mexico today.

## CONCLUSION

In summary, it is entirely consistent to recognize that packaging plays a valuable, often resource-conserving role in the modern distribution of food, beverages and other goods, and to maintain that a large and perhaps growing fraction of packaging is wasteful or environmentally problematical. The most popular specifications of the problem of packaging, based on (often inaccurate) projections of landfill capacity shortages and on the visible prevalence of litter, capture only secondary aspects of its environmental impacts. More serious is the use of natural resources and the emission of air and water pollution in the manufacturing process.

For products or packages that can be made of only one material, recycled content is better for the environment, as is commonly believed. The evaluation of packaging impacts is a more complex task when, as is typically the case, there is a choice of packaging materials. One type of plastic, PVC, stands out as the environmentally worst choice in both the U.S. and Mexico. PVC aside, detailed research on packaging in the U.S. shows that lighter-weight packages are generally better for the environment, even when weight reduction must be obtained at the expense of recyclability. More tentative research in Mexico suggests that reduction in pollution generated by electric power plants could be key to reducing the impact of manufacturing packaging materials—and that the health and environmental problems of landfill scavenging cannot be ignored.