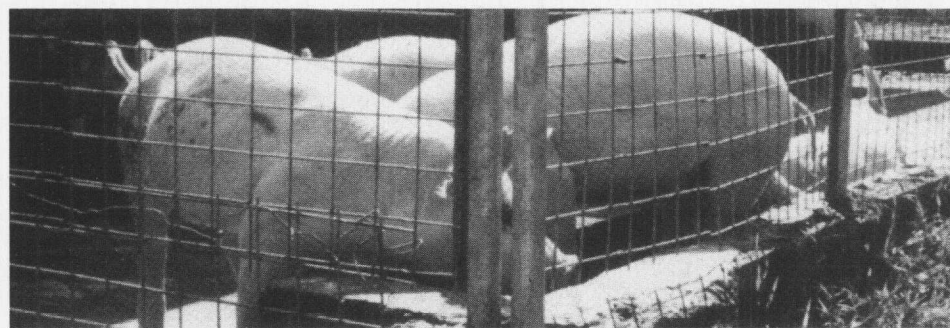


Industrial Ecology

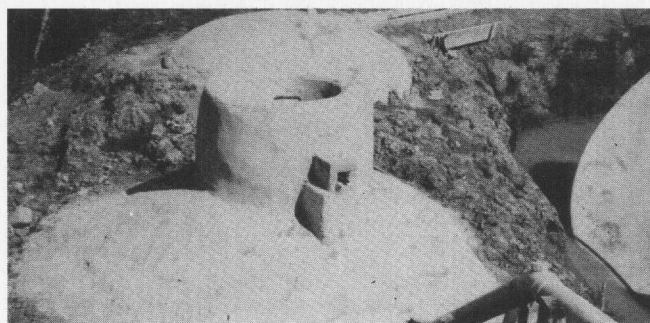
Zero Waste System In Paradise

Boys school on the island of Fiji uses an integrated biosystem to produce vegetables and animal feed from brewery and sugar cane processing.

Robert Klee



The Integrated Biosystems at Montfort Boys Town utilizes mushrooms (grown in houses and racks shown in top photo) which break down bagasse substrate, generating a high value feed for pigs (middle photo). Pig manure effluent flows into anaerobic digester (right), producing biogas used as household fuel.



MOST VISITORS to Fiji come for rest and relaxation on the white sand beaches or for diving and snorkeling among the unspoiled coral reefs. Few visitors realize that this tropical island in the South Pacific, north of New Zealand, is on the cutting edge of industrial ecology with a fully functional, zero waste program located near the Fijian capital of Suva. As part of an EPA funded review of international ecoindustrial parks, I conducted a field inspection of the Montfort Boys Town Integrated Biosystem (IBS) last August to see this emerging agricultural application of industrial ecology.

Montfort Boys Town is a Catholic school that gives free technical courses for up to 150 disadvantaged boys from all parts of Fiji. The IBS was designed by Professor George Chan of the United Nations University in Tokyo, in collaboration with the Zero Emissions Research Initiative (ZERI) Foundation. The IBS operates along a basic concept where the waste from one process is upgraded and completely utilized in another, which results in zero emissions from the system. The IBS system links simple agricultural activities — mushroom growing, pig raising, fish farming, and traditional vegetable growing — in a unique series of material flows to utilize all available nutrients and eliminate the economic and environmental costs of feed, fertilizer, and waste disposal. The system also serves as a general teaching tool for the boys, who are responsible for the daily maintenance and upkeep of the system.

The IBS system at Montfort was designed to primarily accommodate spent grain from beer breweries, which would otherwise be discharged into the sea, smothering and destroying Fiji's world famous coral reefs. The IBS system can also accept bagasse, a fibrous waste from sugar cane processing, which, like the brewery waste, is a free and readily available raw material. The fibrous raw material forms a substrate for growing commercially desirable shiitake, oyster, and straw mushrooms. The mushrooms break down the lignin-cellulose structure of the substrate, generating a residue that is a high value feed for pigs. The pigs are raised solely on a combination of traditional pig feed (vegetable and kitchen scraps) and the mushroom residue, which constitutes a savings of approximately FJ\$10,000 in costs avoided for supplemental pig feed pellets (FJ\$1 US\$0.50). The IBS system can support up



Zero Waste System In Paradise 66
 Earthworms, Mushrooms
 And Zero Waste In China 68
 Diversion Strategies
 When Landfill Tip Fees Are Low 70
 Melbourne Conference Shows Progress
 In Organics Recovery 72

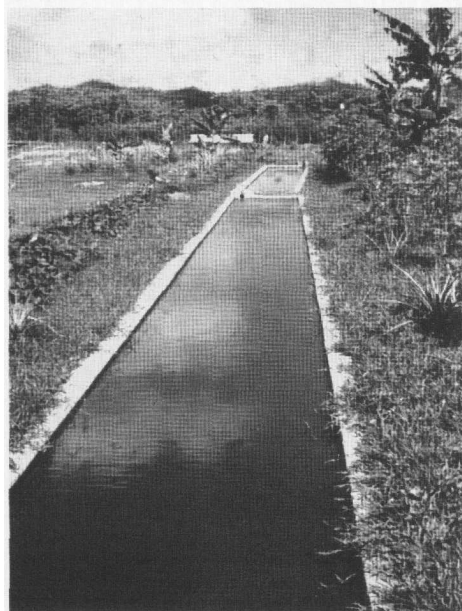
Marketing On-Farm
 Composting Services 75
 Global Roundup 75
 Fruit Juice Processor
 Launches Composting Project 78
 Front And Center With Biowaste 80

to 100 pigs, although the Montfort site only has 50 pigs. Over five months the pigs grow to 120-150 kg, and can be sold at FJ\$3.50/kg in local markets. The pig farming generates approximately FJ\$20,000 per year for the school.

Students wash the manure out of the pig house twice a day with a simple garden hose. The effluent flows into the anaerobic biodigester — the most technical and expensive (FJ\$7,000) portion of the IBS system. This air-tight, reinforced concrete, 20 m³ vessel contains anaerobic bacteria that remove approximately 60 percent of the biological oxygen demand (BOD) from the organic pig wastes. This anaerobic process produces up to eight m³/day of biogas that can run a simple household gas burner for up to 6 hours. Since reinforced concrete is not universally available in Fiji, a new biodigester made from concrete bricks and plaster has been developed. The new biodigester is easier to build and costs FJ\$3,000 less than the reinforced concrete version.

Treating and recycling effluent

After the effluent is anaerobically treated, it flows downhill through a pipeline to a gravity-fed series of three algae ponds. Aerobic decomposition virtually eliminates the BOD and produces a final effluent stream of nutrient-rich water that fills two 3000 m³ fish ponds. The algae is harvested daily and used as feed for live-



stock. The nutrient rich waters permeate the soils in the fish pond embankments, creating fertile soil for vegetables and crops without irrigation or chemical fertilizers. The boys are responsible for growing, tending, and harvesting the crops, which include: eggplant, cabbage, beans, corn, peppers, sweet potato, pumpkins, taro, chili, bananas, cassava, among others. The 150 inhabitants of Montfort Boys Town are completely self-sufficient in eggplant, cabbage and beans. The school generally realizes considerable economic savings from food purchases avoided through farming.

The nutrient-rich water spawns phytoplankton and grasses that form the main food sources for six types of fish, all available for free as fingerlings from the Fisheries Department. The fish species have been specifically selected to feed at different trophic levels in the pond. Two types of tilapia (a white fish similar to monkfish) feed on phytoplankton; grass carp feed on grasses; silver carp feed on dead algae; pontius feed on zooplankton; and common carp feed on wastes from the tilapia. The boys harvest 30,000 fish twice a year, generating a net yearly income of approximately FJ\$30,000/year. Again, the Montfort Boys Town realizes a considerable economic benefit from costs avoided for fish food.

The IBS system has been intentionally designed to grow and adapt to changing environmental, economic, or technical needs. For instance, if no market exists for mushrooms, earthworms can grow on the brewery waste or bagasse, performing the same function as the mushrooms in breaking down the material into a usable form for pigs' consumption. The earthworms can then serve as food sources for chicken farming, whose wastes can be incorporated into the biodigester and thereby into the rest of the IBS system. The biogas produced in the digester could be bottled or piped for use in

Nutrient-rich water in fish pond aids vegetable crops growth along embankments. Algae is harvested daily and used as livestock feed.

a small power generator. The surfaces of the ponds may also be used productively through aquaponic farming on floating rafts. These rafts could grow economically viable flowers, or additional food crops such as cereals, cabbage or lettuce. The slow flow effluent from the ponds (currently discharged into a local river) could be diverted to irrigate a larger taro patch, to utilize the last remaining nutrients in the water. Finally, mud carp may be in-



Pineapples are among the many food crops harvested at the school, which realizes considerable economic savings as a result of its closed loop system.

roduced to the ponds to eat an invasive snail species that is competing for food.

The Montfort Boys Town is a clean, organized and lush oasis in an otherwise dry, dusty, garbage-strewn, and impoverished landscape. As shown in the success at Montfort Boys Town, the general IBS system offers a way to create more jobs, increase income, and produce better quality food in an ecologically sustainable way. This is particularly important in developing island nations, which have limited land area, fresh water, and local fish stocks. By selecting mushrooms, fish, vegetables and livestock that are best suited for the local climate and available materials, the system can be applied in nearly any location around the globe. ■

Robert Klee is in the Industrial Environmental Management Program at the Yale School of Forestry and Environmental Studies in New Haven, Connecticut.