SP.717 (D-Lab) Spring 2005
Session #24 notes

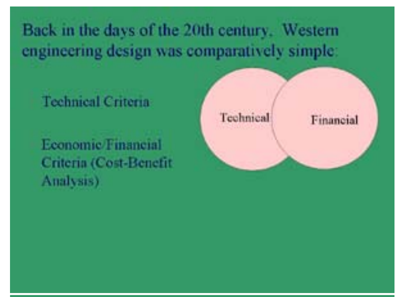
Co-Evolutionary Design

Guest lecturer: Susan Murcott, Principal Investigator and Research Engineer in MIT's Civil and Environmental Engineering Department; focuses on water and sanitation engineering projects in developing countries

This lecture is based on one given by Susan at the *Engineers for a Sustainable World* conference (Stanford University, Oct 1 2004).

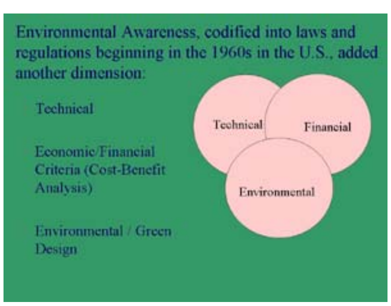
This talk is about taking the design process through the stages that her design teams have gone through. It should be a hopeful message, because the talk shows all the hard work that happens in the process of bringing an idea into the field.

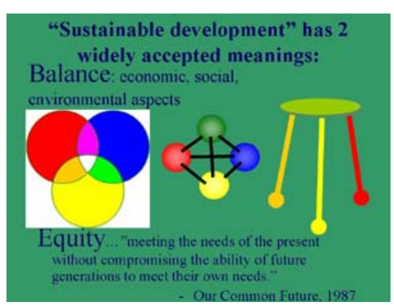
20th c Western engineering design used to be based on fairly straightforward criteria of cost and performance.

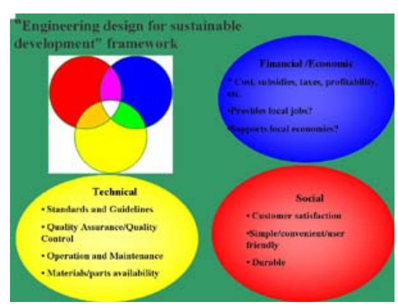


In the 70s, E.F. Shumacher published *Small is Beautiful* which introduced the idea of "appropriate technology" and in that same era, environmental considerations were newly brought into public awareness and the design process.

In the 80s and 90s, sustainable development considerations have been added. What's sustainable development about? It's a balance among economic, social and environmental aspects.



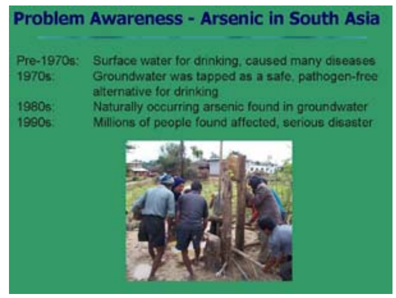




Susan is a water engineer; she is continually asking, "Who needs the development for water projects?" These questions lead to a "co-design" or "co-evolutionary" design process.

It may be that for a new cell phone or computer chip, you can design it in the lab; but you can't do that for a water project, moreover, you can't be a 1st World engineer designing for a 3rd World community, without engaging the community and the users in a co-design or co-evolutionary process.

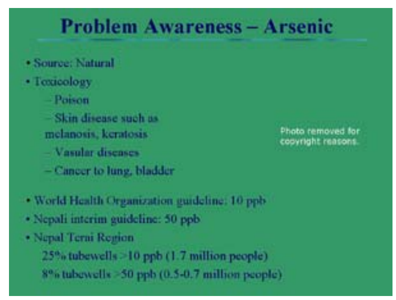
Problem Awareness through Partnership



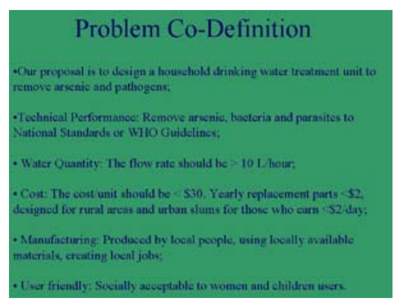
What's the country/region/community? What are the problems? In Nepal, where's the arsenic? How does this problem also affect South Asia, New Mexico, New Hampshire? How does the arsenic affect people?

Partnerships with local organizations are central to doing this work, to getting awareness.

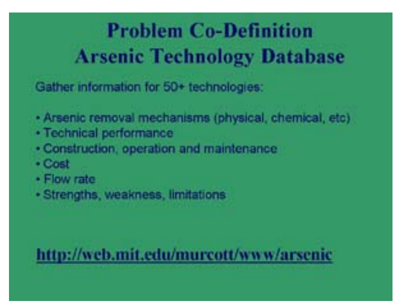
Problem Co-definition



In year 2, 3, 4 of a project, the perspective of co-definition leads to continuous refinement in understanding the problem and potential solutions. Statements about application, technical performance, cost, manufacturability and social acceptability all evolve toward the most appropriate solution.

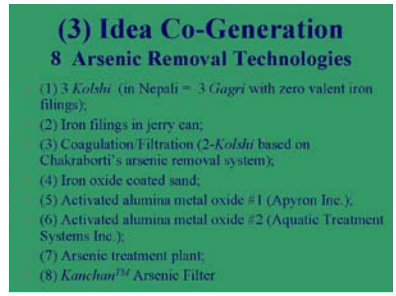


Take the case of water development projects in the 1980s. The U.N. goal was all about water supply and microbial safety, with a strong bias that groundwater was inherently better than surface water sources like rivers. Water quality testing being hard and expensive, it wasn't done extensively…of the millions of wells in Bangladesh, it took 15 years of using these new water supplies before arsenic testing was put in place. Don't lose sight that millions of childrens' lives were saved by alleviating the microbial contamination that resulted from switching from very dirty surface water sources to groundwater supplies; but realize there are also potential unintended consequences and so many other things to also watch for.

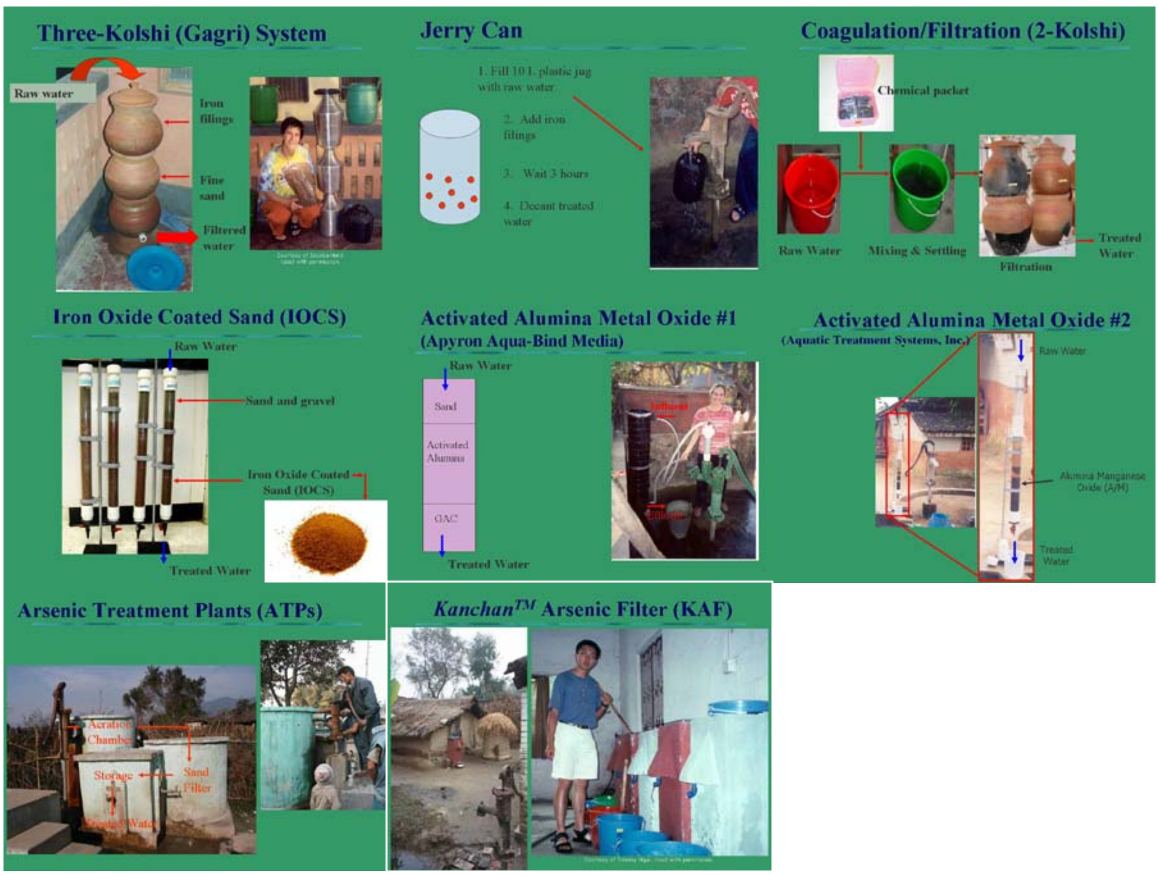


Now there are hundreds of millions of people around the world affected by arsenic-contaminated groundwater supplies.

Susan has supervised many arsenic-related thesis projects, with months-long field testing experiences. For example, iron filings (scrap from iron fabrication) and iron-heavy sands are among the materials being evaluated.

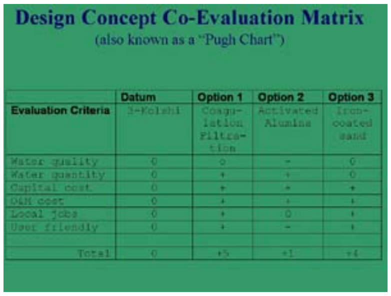


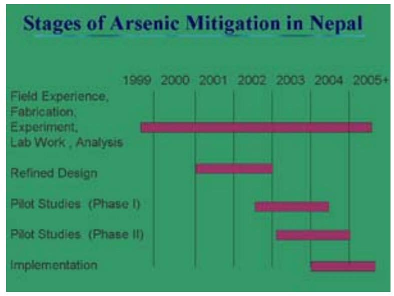
How does an idea get refined? In a three-pitcher or 3-kolshi vertical filter with sand and iron filings, problems included a slow flow rate and being prone to clogging. Furthermore, iron filings originally obtained from Pennsylvania were not locally available in Nepal. What kind of local iron products are available as alternative? They found a nail shop w/ both galvanized and ungalvanized nails. Rusty ungalvanized nails are a great adsorption media for arsenic removal.



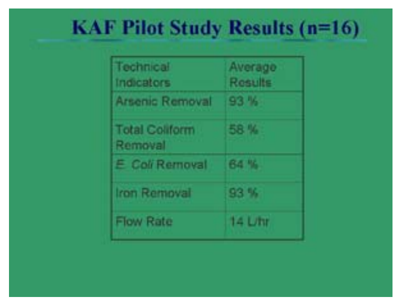
Concept Co-Evaluation

The class looks at Pugh Chart comparisons of working water filter designs through Fabrication, Lab Work, Analysis, Refined Design, Pilot Studies, and Implementation.





In a comparison of technical, economic, and social criteria, three of the eight designs excelled. These three were pushed ahead into Phase II evaluation and pilot studies.

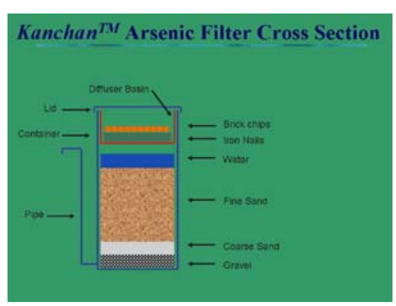


What are the expectations on water quality, i.e. coliform removal? The WHO has a recently updated spec, 3rd edition, which acknowledges different communities have differing abilities to realize targets…accommodates some collaborative planning. See http://www.who.int/water_sanitation_health/dwq/en/.

Slide shows a diagram of "Kanchan" Arsenic filter; this was a winner in MIT IDEAS competition, ~2003, which gave working funds for refinement and Phase II.

Q: Why have coarse sand and gravel at the bottom, below the fine sand?

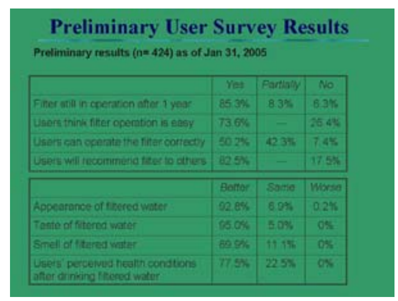
A: These coarser media are simply there to protect the pipe.



The World Bank "development marketplace" competition in 2003 awarded $115k to the Kanchan Arsenic Filter. In the contest, there were 85 finalists and 42 winners out of ~2,700 applications.

Tommy Ngai, the student that led the group, has been in Nepal for the past 2 years, working with local partners to refine the design and build local resources. Design has evolved from custom-made concrete (too expensive, too slow to build) to a plastic bucket design. Sloan School "G-Lab" students have contributed in the past couple of years.

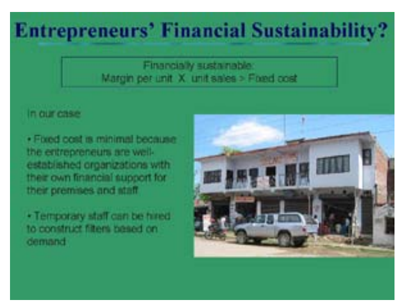
This project has trained 15 local entrepreneurs; taught workshops in ~30 communities; distributed 2,000+ filters as of Jan. 2005.



Now they are conducting a User Survey. Preliminary results are considered very favorable: 85% of filters are still in operation, and 82% of users would recommend filter to others.

Summary

Does the filter meet our goals for Co-Evolutionary Design? It seems so…the unit costs about $16 to make, and the entrepreneur makes ~$5 profit. At this early stage, the entrepreneurs use this as a side business rather than their sole source of income. But the goal is for a tremendous ramp up – only 2000 units so far, but they hope to reach 700,000 people.



Kanshan is not the sole solution for Nepal – other technologies may be more appropriate in other situations. And the same goes for other countries.

Related links:

MIT Civil and Environmental Engineering (CEE) web portal on household water treatment and urban and rural sanitation projects in developing countries. http://web.mit.edu/watsan

Arsenic Biosand Filter Project, via World Bank http://web.mit.edu/watsan/worldbank_summary.htm