

Symbiotic Recycling Systems for Creating Sustainable Habitats

Ramesh Dave, and Gauranga Das

Abstract— There is a steep rise in the volume of the waste generated due to rise in population. Conventional waste Management systems based on linear resource to trash concept are proving to be ineffective and often ecologically disastrous in dealing with it. The Waste management process in Nature is cyclic in nature where in waste from one process acts as raw material in another process thus avoiding the need of expending any energy in processing the waste. Govardhan Eco Village (GEV), a 100 acre farm community has successfully implemented this Symbiotic Model for Waste management and is being able to process all kinds of wastes and utilize them in other processes thus creating economic benefits out of it. In this way GEV is able to resolve the dichotomy between ecological and economical sustainability.

Keywords— Sustainability, Symbiotic Recycling, Waste Management, Waste Recovery.

I. INTRODUCTION

WITH India looking forward to regain 8% growth rate, economic pundits are strongly advocating expanding the manufacturing sector as the way to move ahead. Historically it has been observed in various world economies that the manufacturing sector has had a positive influence on the nation's growth rate. Policies governing the manufacturing sector have always aimed towards improving the economy, but have laid little or no emphasis on the impact of such a growth on the ecological infrastructure of the nation. It's a tricky challenge as the systems that are aimed towards improving the economy on the short term, can potentially prove detrimental to the very infrastructure that sustains it in the long term.

This dichotomy has created a scission among thinkers who have developed opposing views towards economic sustainability and ecological sustainability, deeming these two paradigms to be incompatible. However for a nation to achieve a balanced growth this dichotomy has to be reconciled. The United Nations in its Millennium development goals [1] set targets for simultaneously improving both the socio-economic conditions of people and ensuring environmental sustainability.

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II. IMPACT OF MODERN DEVELOPMENTAL SYSTEMS

Developmental systems adopted today have failed to acknowledge the aspect of ecological resilience [2] or nature's capacity to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks. Our modern developmental systems have been formulated on the premise that nature has abundant resources and have hence adopted a linear model of "resource- to- trash" systems. They take resources from nature, process them into a useful form and at the end of life-cycle dump it back into nature in the form of waste. Wastes are also generated at various stages in this model, whose handling costs are offloaded into nature. This model has worked for decades and has successfully improved many world economies. However this model can't sustain long because what has been presumed as nature's capacity to produce unlimited inputs and accept unlimited waste, was its mere persistence in the face of changes in ecosystem variables due to anthropogenic causes [3]. With more nations of the world adopting this model there is an increasing strain on the planet's ecological resilience resulting in effects like global warming, climate change, loss of biodiversity, food shortage etc. In order to mitigate these effects, a significant amount of financial resources are being spent in the form of environmental protection measures and offering subsidies to the affected populace. Thus the modern developmental systems are straining the economy and proving to be counterproductive.

III. URBANIZATION IMPACT

A direct consequence of the modern developmental model can be perceived in the abnormal growth in the urban population. The 2011 census report shows that for the first time in independent India the absolute increase in population is more in urban India than rural India. The trends are no different globally. For the first time in the history of humankind, urbanization has increased at such a massive pace, that more than half the world's population today lives in towns and cities. By 2030 this number is expected to swell to almost 5 billion, with urban growth concentrated in Africa and Asia [4]. This essentially means an undue overload on the urban infrastructure which have not been designed for such inflated numbers. With all modern cities being based on the resource-to-trash systems, one of the key areas that will be badly hit are waste management systems. Predictions are that waste management is going to be one of the planet's biggest

concerns in decades to come [5].

Current waste management techniques like landfills and incineration were devised decades ago when the population density was relatively low. With rising population and steep rise in the volume of waste generated the ecological resilience is being tested to its full capacity. Conventional waste management techniques are proving to be ineffective and ecologically disastrous. In spite of the glaring ecological hazards posed by these techniques they continue to prevail especially in third world nations. Separate segregation and recycling of waste, though a highly effective solution, is not being taken up on a wide- scale due to various technical and financial challenges they pose.

IV. SYMBIOTIC RECYCLING SYSTEMS

This dichotomy of sustainable economic and ecological development can be harmonized by a close examination of nature, its systems, processes & constituting elements. Nature also has an extensive method of development, evident by the wide variety of life forms it successfully nurtures. The well being of any model can be understood by examining the ease with which the various systems in the model function and how the individual elements constituting each system have a sustained growth.

Nature has a very unique way of waste management. Before we understand that, we need to understand what waste is. Waste can be defined as any object that neither in partial nor in totality contribute to the end goal of a system. Such an object may be produced as a “delayed waste” or as an “immediate waste” in a system. For example, in a manufacturing process, there are wastes generated at various intermediary stages in the process, constituting the “immediate wastes”. And the final good produced thereby will also eventually, at the end of its life cycle, be trashed constituting the “delayed waste”. The systems comprising the developmental model in nature are in such a way that the wastes from one particular system can be used as raw materials for another system, that way there is no extra energy expended in processing the wastes. In other words, what comes from nature from one system goes back to its proper place in nature in a different system where it is processed and used. Thus the various systems in nature develop a symbiotic dependence on each other and the wastes produced in various stages are recycled within the model. This concept is called Symbiotic recycling.

The modern developmental models are all comprised of disconnect individual systems that follow the resource-to-trash concept. At every stage in this model each system acts like an individual consumer, consuming resources and producing waste. Thus the overall waste produced from this model is very high. If we can formulate models comprising of symbiotically dependent natural systems then we can incorporate an inbuilt mechanism of recycling and save all hassles of waste management. Such a model then would not be an integration of consumers, but a symbiotic integration of contributors. By developmental models formulated around this concept of Symbiotic recycling we will be able to achieve

the desired objective of improving the quality of life and also ensuring environmental sustainability.

V. GOVARDHAN ECO VILLAGE – A CASE STUDY

Govardhan Eco Village (GEV) is a farm community set up to highlight the importance of living a life in harmony with nature. Unlike the modern day resource-to-trash systems, GEV is an integration of various symbiotically dependent systems. At the heart of this model is organic farming and cow barn, the traditional symbols of sustainable living. The farming system produces enough grass and feed for the animals and the cow barn system produces manure and cow-urine derivatives which provide other necessary ingredients for farming. These symbiotically dependent systems have a built in mechanism of waste management and in return produce grains, vegetables, cloth, natural medicines, milk and other cow products. Thus a self sustainable cycle was established that meets our bare minimum needs

Around this basic model we added buildings for human settlements. The challenge was to make buildings that were not only aesthetic and comfortable, but would also create minimal impact on the environment. So after a thorough research, we started making green buildings using an improvised mud brick technology called compressed stabilized mud blocks (CSEB). Unlike the commonly used baked bricks these unfired bricks retain mud's natural property of maintaining optimum temperature. Thus buildings made with these bricks would remaining cool in hot weathers and warm in cool weathers, thus saving a lot of energy in heating and cooling systems. An entire structure made from these bricks have less than 1% the embodied energy as compared to their fired brick counterparts [5].

So with food and shelter in place our focus was then to ensure a sustainable water source for the village. So we undertook a thorough survey of the ground water flow patterns, called as a hydro-geological survey, and identified ideal locations for extracting water. We also made a facility to recharge the ground water and created various rain water harvesting structures that would serve all the water requirements of our growing community

With a growing community in place our biggest challenge was waste management. Our intention was to set up symbiotic systems that would harness nature's inbuilt concept of recycling. But at the same time we were also conscious that not any kind of waste could be handled by this natural system, for example highly toxic industrial effluents etc. So we had to simultaneously imbibe in the eco village a culture of using compatible materials. This perhaps is the most important step in the long term sustenance of this model because as much important as it is to create right systems, it is also important to train the people using these systems.

Thus the nature of wastes produced in the eco village was mainly four fold:

- 1) Animal Waste and other wet wastes like food wastes etc.
- 2) Dry biodegradable wastes like foliage, paper etc.
- 3) Dry non-biodegradable wastes like plastics, construction aggregate etc.

4) Human wastes, which constitutes the sewage

To take care of the first category wastes, we added biogas plants that accept wet food wastes and cow dung from the barn system and give out digested slurry, which acts as an organic fertilizer input to the farming system. The biogas thus produced is used in cooking thus generating savings on LPG bills. We also set up various composting pits that takes in other organic wastes like paper, foliage etc. and produce compost for the farming system.

Construction wastes like broken cement poles and bricks are utilized in making permanent raised beds (PRB) for farming. The PRBs are an innovative way of saving human labor, tractor usage, energy and time before cultivation. The land is prepared by creating these raised beds from cow manure, leaves, compost and soil. These beds are permanent and are more fertile and conducive for growing vegetables and fruits. GEV was recently listed among the top 100 agricultural innovators for effective usage of PRBs. The entire boundary of the PRB is made by construction wastes like cement poles and bricks, creating a symbiosis between farming and construction systems. Other construction wastes like quarry dust (an ingredient in making CSEBs) and construction aggregate was used in cob house construction and in repairing the roads. The broken red bricks are being used in water proofing the roofs in other constructions. Waste card board cartons and cloth are used as mulch in the agriculture field. Mulch is a protective cover placed over the soil to retain moisture, reduce erosion and provide nutrients. Spreading the waste card board cartons and cloth on the land also blocks sunlight, thus preventing growth of any weeds. By using this simple technique one can avoid the labor intensive task of removing weeds or usage of any chemical weedicides.

Cement Bags and other plastic bags are utilized to store mud and compost. It is also used to grow plants, esp. grasses like kusha – whose fragrant roots can be easily extracted by cutting the bag open. Wood dust, produced by sawing the wood used for construction, forms an ingredient along with cow dung, in making of dhoop sticks or chemical free incense sticks. Not only are these dhoop sticks fragrant, but also have the utility of being a chemical free mosquito repellent. An entire cottage industry is run in GEV which takes as raw ingredients cow dung and cow urine and manufactures various chemical free products like dhoop sticks, tooth powders, soaps, bathing powder.

VI. NEED FOR SAFE SEWAGE TREATMENT

The final category of waste, namely human waste was a serious issue to be dealt with. Initially we adopted the standard practice of septic tank based sanitation systems. However in due course of time it was found that this process was leading to foul odour, mosquito breeding and stagnation of water due to poor permeability in black cotton soil. Also it was ecologically unethical to dump the contaminated septic tank water into water bodies directly. So we required an alternative technique meeting the following requirements:

- 1) An ideal sanitation model to practice in a self-sustaining rural, sub urban and urban community.
- 2) Saving of ground/surface water resource via recycling of waste water for secondary usage like irrigation of farm
- 3) Generate photosynthetic biomass for internal use (flower, fruit, and excess biomass for green manuring)

VII. SOIL BIOTECHNOLOGY

Soil Biotechnology (SBT) is an indigenous green technology for sewage processing for recycle and reuse of processed water. SBT has been developed & patented by Chemical Engineering Department, IIT Bombay. In this system combined grey water and black water streams are collected and transported via gravity driven underground sewerage network up to the raw water storage tanks. Raw sewage is then pumped and distributed over the SBT bioreactor through a network of pipes

Organic solids and liquid wastes of human activity contain both energy and nutrients. Unless harnessed, they pollute the environment. Conventional sewage treatment technologies fail to achieve this. As a result the non-utilized nutrients accumulate and disturb the natural balance of soil, water and air through overloading. Salinity, pests, diseases are symptoms of this phenomenon. SBT synergistically engages photosynthesis, respiration and mineral weathering - the three fundamental processes of Nature, to bio- convert organics and inorganic in sewage. This is achieved by soil micro-organisms and regulated by soil macro-organisms viz. geophagus earthworms etc. As a consequence the organic waste constituents of the raw water are consumed and simultaneously water of desirable quality is produced. SBT removes BOD, COD, ammonia nitrogen, nitrate nitrogen, suspended solids, bacteria, color, odor - all this in a single "all green" system open to atmosphere. The processed water (after multiple passes if necessary) is collected in an intermediate collection tanks. The final treated water is recycled for farming and in use in the GEV nursery

VIII. ADVANTAGES OF SBT

A. Sustainable

Conventional sewage treatment systems are characterized by high mechanization and are highly energy intensive. Consequently the operations & maintenance is very tedious and cost intensive. As a result, in many cases the plants are not in operation, the ground water is polluted and treated water cannot be reused. SBT stands out as a very sustainable cost- effective solution to the problem of waste water management, specific to the Indian climatic, social and environmental conditions. Besides the process being natural, it depends very little on external energy sources and conserves the same

B. Recovery Efficiency

The only water loss in SBT systems is due to evapo-transpiration from the plants and soil. Therefore the treated

water recovery is very high. Recovery of more than 90% has been observed under all climatic conditions.

C. Power Saving

Use of SBT system results in substantial saving in electricity cost, as power usage is for pumping alone. The comparative data is as follows for the envisaged capacity of 100 KLD.

Power for SBT system – 36 units per day

Extended Aeration Process – 200 units per day

Total percent saving = $(200 - 36) * 100 / 200 = 82\%$
approximately¹

Though SBT's functioning is aligned with nature, it is intensive enough to fit in a typical urban scenario that is scarce on space. An SBT system is quiet & green. It's deceptive look hides the intensive processes that are based on sound principles of terrestrial (soil-plant) ecology. Therefore, the quality of SBT processed products be it treated water or bio- mineral fertilizer, are by far superior to any other systems. Therefore, it qualifies for an ideal zero discharge system

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¹ NOTE: SBT power estimate does not include requirement for distribution of treated water just as in all other conventional systems.