SYSTEMIC DESIGN FOR THE RECYCLING OF SOLID AND LIQUID ORGANIC WASTE AND THE HYDROPONIC GROWTH OF ORGANIC FOOD: A NATURAL CYCLE OF LIFE

Peon-Escalante I.*, Turpin-Marion S.[2], Sanchez-Gongora A.[3]
* IPN, SEPI, ESIME Z, Mexico D. F., ignaciopeon@gmail.com
[2] UAM, Unidad Azcapotzalco, CBI, Mexico D.F., stm@correo.azc.uam.mx
[3] IPN, SEPI, ESIME Z, Mexico D. F., mariaantonieta_gongora@yahoo.com.mx

ABSTRACT

We propose a systemic design for the total recycling process of solid and liquid organic waste, its anaerobic and aerobic treatment, and the production of organic food through the use of hydroponics under a controlled environment. In Mexico City, as in many other cities in the world, waste management is a growing problem, solid and liquid, organic and inorganic. One half of solid waste in Mexico City is organic. The city government also has considerable difficulties with the disposal of waste. Another relevant issue is the availability of water for Mexico City's, 20 million inhabitants. At the Instituto Politecnico Nacional (IPN), a large and influential public university in Mexico, a technical research project has been designed to provide a systemic solution for these important needs.

In nature, there is a Cycle of Life in each of the biotic parts of an ecosystem there is a synergetic relationship between biotic and non-biotic systems. When a living being dies, its organic waste becomes a favorable substrate for decomposers, in the organic waste, living beings obtain water and nutrients for their growth. The main composition of living beings is water. We can observe how ecosystems work, and use an ecosystemic metaphor for a systemic design of a recycling process.

A systemic socio-technical solution is being developed under the conceptual guideline of the ecosystemic metaphor through a participative action-research process to design an integral solution to the problems of waste, water and food production. For almost thirty years we have been working on this type of solutions alongside rural and urban communities, the next step is to optimize the recycling and construction process with an action-research systemic project on its technological, economic, social and environmental dimensions.

Keywords: Cycle of Life, ecosystemic metaphor, participative action-research process

INTRODUCTION

The systemic application of the socio technical applied research evolved from the complex problems of one of the largest cities in the world, Mexico City. In this great metropolis, 20 million people have been affected by two increasingly dire conditions:

water shortages and lack of space for treatment, storage and recycling of waste materials. These problem situations overwhelm the institutional and economic powers of the city's government.

Under these conditions, this applied systemic research is focused on the integral management of organic solid an liquid domestic waste, all of which are nutrient rich (United Nations Human Settlements Programme). Treated organic waste may be reused for the production of fruits and vegetables of high nutritional quality, in a controlled environment and for reuse of water in rural and urban settings.

To grow organically fertilized food of quality from solid and liquid residues, it is necessary to treat the water and organic waste from the above-mentioned sources. A transdisciplinary process of research action is used in the design of the social and technical system, that includes the integral treatment and recycling of waste for food production and the social process of research, training and social organization needed to implement and promote this systemic technological innovation

CONTEXT

Water management in Mexico City and the rest of the country

As much water as 1,781 m^3/s (56.2 km^3 per year) is destined for agricultural use, 67.2% of which comes from superficial sources and 32.8% from subterranean deposits. Water reuse in agriculture is a valuable alternative in all the arid and semiarid Mexican states, given the current levels of discharge of 200 m^3/s (6.3 km^3 per year), over half of which (108 m^3/s or 3.4 km^3 per year) is used in irrigation.

Only 8.2% of water goes through any treatment process, while 91.8% of water used in all 254,597 ha of our 26 Irrigation Districts (ID) remains untreated. District 03 in the Mezquital valley, with 90,000 ha and a 105 year history of continuous use is noteworthy for its exemplary use of residual water. This district represents 43% of the volume and 34.4% of the total national area cultivated under such conditions.

In Mexico, water reuse in agriculture dates back to 1896, although it was only in 1920 when the economic importance of its use became clear. It may be stated that use of this water was a spontaneous, unpredicted and unplanned consequence of the water runoff projects in the Valley of Mexico City (Jiménez et al., 1998) towards the Mezquital Valley in the northern border of the city. This nutrient rich water is highly valued by agriculturalists due to the enhanced yield effect observed in the crops. However, against existing health norms, the water is used untreated, and concern for health risks in the consumer population remains very high.

Management of solid organic waste

Generation of urban solid waste represents a serious concern in the country. In Mexico City alone, 12,500 tons of waste are produced daily, 55.58% of which is organic in nature (PGIRSDF 2009 – 2014, 2009).

Within a sustainable development context, the fundamental objective of any strategy of integral management of solid waste must be the optimization of resource use and the prevention or reduction of any adverse environmental impacts deriving from said management.

Integral waste management combines flows, collection methods an procedures, aside from a series of normative, financial, planning, administrative, social and educational actions of monitoring and evaluation, from which derive environmental benefits, economic optimization and social acceptance (SEMARNAT, 1999, 2001).

Current tendencies focus on separation programs that allow for selective management to recover any waste material that may be reused as matter or as an energy source.

For organic waste, use of materials is in the form of compost production and production of animal feed, among other uses. The common denominator of these methods is the creation of a useful organic product, from discarded organic material.

In the case of inorganic waste, use of residue is made though reuse and recycling (Ley General para la Prevención y Gestión Integral de los Residuos, 2003), (Ley de Residuos Sólidos del Distrito Federal, 2003).

The key point is not the number of treatment options that may be implemented, or even whether these options are applied jointly, but rather that they are part of a strategy that meets the local or regional needs and contexts, as well as the basic principles of the relevant environmental policies (SEMARNAT, 1999, 2001), (Gutiérrez A., V., 2006).

In Mexico City, there are nine organic waste composting plants, with a total daily capacity of 88 tons, using as its primary source the organic component of urban and landscaping residues (PGIRSDF 2009 – 2014, 2009).

Solid urban waste is constituted by the following components: food waste, landscape waste and similar organic materials (México. Tercera Comunicación Nacional ante la Convención Marco de las Naciones Unidas, 2007).

According to the reports, the largest fraction of waste results from domestic sources, representing as much as 77%, while the remaining 23% corresponds to various other sources.

It is interesting to note the increment of the average per capita indicators of waste generation, where the rate increased from 1.4% to 2% in the period corresponding from 1997 to 2010, a violent growth of 43% in 13 years.

With respect to the type of domestic sub-products created, those of organic composition correspond to a fraction of 55.6%, while the remaining 44.4% are of a diverse nature. Of the totality of collected waste materials, the final disposal in the year 2000 was executed in the following manner: 47.1% in landfills, 7.9% in controlled soil deposits, 42% in open air areas and 2.4% was recycled. These percentages changed to

54.3%, 10.4%, 32.0% and 3.3% respectively by 2005 (México. Tercera Comunicación Nacional ante la Convención Marco de las Naciones Unidas, 2007).

Mexico accounts for about half of the 500, 000 ha irrigated with wastewater in Latin America Much of the recent scientific work on health impacts and other aspects of wastewater use has been done in Mexico. In most cases the wastewater is used at some distance from the urban centre in a formal irrigation setting. The bulk of the untreated wastewater from Mexico City goes to Mezquital, immediately north of the Mexico Valley where it is used for irrigation canals. This is probably the largest and longest-standing wastewater use system in the world (Scott, *et al*, 2004).

SYSTEMS THINKING

We use the following relevant concepts as our theoretical framework:

- *The Ecosystemic, and Cycle of Life metaphors*
- *Transdisciplinary knowledge*

Characteristics of the Ecosystemic Metaphor: A complex metaphor for heterogeneous socio technical systems

In each ecosystem there are two main types of systems: living, and a non-living. The open socio technical system deals with non-living systems, or infrastructure (different kinds of tools, buildings, programs, and products), and conscious social organizations.

An important part of the living chain is the trophic process, each living being at different times of their life cycle forms part of the food chain. Each subsystem has inputs, and outputs of matter-energy, and information. In each transformation process of an open socio technical system there are also inputs, and outputs. The transformation process of inputs into outputs changes their organization, or complexity level.

Each ecosystem has a great variety of organic systems, and inert systems, a dynamic network of complex complementary relationships in a life cycle. It is a unity in diversity with emergent synergetic effects. The open biological, and socio technical systems in their different stages of their life cycle reach alternative, and complementary forms of equilibrium (entropic, homeostatic, morphogenetic) in their long-term evolutionary process towards sustainability.

In the evolutionary transformation process of living beings, emergent properties appear when they reach higher levels of complexity at different recursive levels. In creative socio technical processes of transformation, emergent properties also appear as scientific, technological, or organizational breakthroughs.

Each type of biological, and socio technical system has a particular long-term identity, a structural stability achieved through an autopoietic process toward sustainability, through a dynamic homeostatic process of equilibrium.

For the design of the socio technical systemic process for the integral use and reuse of water and nutrients with the participation of local communities and their organizations we use as a guideline the ecosystemic and cycle of life metaphors

Transdisciplinarity: A new form of knowledge that integrates and harmonizes the diverse forms of knowledge that have emerged in different stages of cultural evolution

"In the transdisciplinary neither the one nor the other predominates"

Gregory Bateson

"Transdisciplinarity is a generalized transgression that opens up a limitless space of freedom, knowledge, tolerance and love"

Basarab Nicolescu

Disciplinary research concerns, at most, one single level of reality; moreover, in most cases, it only concerns fragments of one level of reality. The indispensable need for *bridges* between the different disciplines is attested to by the emergence of pluridisciplinarity and interdisciplinarity in the middle of the 20th century. *Pluridisciplinarity concerns studying a research topic not in only one discipline but in several at the same time*. Interdisciplinarity has a different goal from multidisciplinarity. *It concerns the transfer of methods from one discipline to another*.

Transdisciplinarity is nevertheless radically distinct from multidisciplinarity and interdisciplinarity because of its goal, the understanding of the present world, which cannot be accomplished in the framework of disciplinary research. The goal of multidisciplinarity and interdisciplinarity always remains within the framework of disciplinary research. *Disciplinarity, multidisciplinarity, interdisciplinarity and transdisciplinarity are not unlike four arrows shot from a single bow: the bow of knowledge*.

As the prefix "trans" indicates, *transdisciplinarity* concerns that which *is* at once *between* the disciplines, *across* the different disciplines, and *beyond* all discipline. Its goal is *the understanding of the present world*, of which one of the imperatives is the unity of knowledge.

The deep frame of reference of transdisciplinary knowledge has an ethical character, it has a philosophical base, it is the dimension of greater profundity of knowledge of all complex systems, it is the dimension that achieves integral sustainable processes of quality by linking complexity and knowledge.

The integration of different disciplines or the meeting of experts in a multidisciplinary manner signifies transcending beyond academic wisdom, being and feeling the global ambience in which we live. It makes us aware of our role and our responsibility as human beings on the planet and it uncovers the need for the enrichment of the truth through integral or systemic reflexive dialogue. It is linked to sustainability of the planet and all its forms of life and culture. Transdisciplinarity is a path to be followed by researchers and by all who are searching for learning toward wisdom, toward recovery of their own equilibrium.

For the Participatory Action-Research process the transdisciplinary approach to knowledge is essential, in the systemic intervention we use different and complementary types of knowledge of a wide variety of experts with practical and theoretical knowledge with different visions.

SYSTEMS METHOD AND PRACTICE

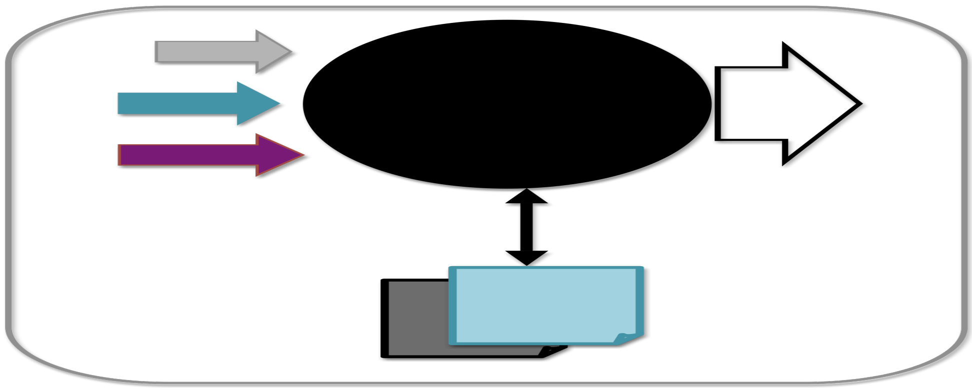

Figure 1- Participatory Action-Research cybernetic method

For the systemic application of the socio technical applied research we use transdisciplinary knowledge from a relevant group of experts with practical and theoretical knowledge, all of them have different visions of their reality. The method is a cybernetic iterative process that integrates data from the different sources of information of each community in their geo-cultural context. The process of design, application, evaluation and creative improvement of the new technical tools and the social process is a long-term process. The guideline for the strategic design process, are the Ecosystemic and Life Cycle Metaphors. Every time we answer research questions, many more emerge.

CONCLUSIONS

We have been working on this process for several decades with urban and rural communities in Mexico, yet we still have many unanswered questions in this complex process for the technical and human aspects of the design process and its results. In this new stage we are looking for new answers to many questions we have on this long-term process of systems thinking and practice. It is a relevant long-term systemic project that addresses not only basic needs of the communities but human organizational processes for integral sustainable transformation

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