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# Strategic Analysis of Alternatives for Waste Management

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## 1. Introduction

Cities, large and small, generate sizable amounts of solid waste. Solutions to this problem are many and range from dumping sites and landfills to sophisticate recycling and treatment schemes. This chapter proposes a model for public policy making which considers the cost and benefit of different alternatives to handle the wastes for a time horizon of 20 years. Combinations of several alternatives: Recycling, waste reduction, waste separation, incineration, land filling with lixiviate treating and gas energy recovery, and organic waste composting are considered and modelled and the results presented as a contribution for a more rational approach to policy making than the one currently being employed.
The chapter puts emphasis on the role of ideas and beliefs in the shaping of public policy and in the need to review the belief system of the responsible bodies and of the community, as related to creativity, planning, long term considerations, sustainability, economics, perspectives and view points changes. A review of possible alternatives for solid waste handling is presented, accompanied of some simple models for calculating basic treatment costs, estimate environmental and energy impacts, mass balance flows, resource requirements, labour impact and required time table for rational execution of associated projects.

## 2. The solid waste problem in cities: a major opportunity for strategic planning and for developing community environmental awareness

The solid waste problem has not been solved efficiently by humankind. Strong forces conspire to make this an awesome problem, among others:

- The consumption habits that dominate modern life, with all kinds of attractive packages for everything and publicity attracting the consumer to increasing expending and to the use of goods that gives rise to amazingly large quantities of disposable materials that have to be dealt with as waste.
- Public awareness that resists the old methods to handle waste and limits the possibilities of landfills and incinerators and that wants waste handling facilities located far away from people's living and working quarters.
- A tendency of the waste materials to be easily mixed and contaminated, following entropy laws of disorder, which diminish severely the recycling and recovery options and makes much more costly to pick, transport, clean, separate and treat the waste.
- A tendency for people to get away from waste handling and recovery, as mixed waste is associated with offensive odors, sticky and nasty textures and ugliness.

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- More and more demanding norms, regulations and laws, that limit the options available and increase the costs of waste handling.
- A constant creation of new and more complex materials, that enter the solid waste chain and put severe demands on prevention of damage and avoiding any negative aspects of solid waste disposal, recycling and reuse.

On the other hand, new opportunities arise such as:

- Job creation will be associated with the recycling, waste and recovery processes. Quality work is required to separate, classify, transport, treat, dispose and recover materials and handle waste.
- Creativity will be required to found ways of recovering the materials and treating the waste. Creativity will always be a welcome human trait that will add to happiness and prosperity.
- Technology developments will create jobs and economic success.
- Scientific finds will help to clarify life cycle issues and to diminish fears once solutions are found for the problems.
- Collaboration between sectors and interest groups will help people to live wisely together and to support community projects.

## 3. Strategic planning

Planning is an attempt to do things in an organized way, trying to define paths to develop the activities related to a given project. A project is the response to a given need and is specified trough objectives and activities to attain them. Planning organizes the activities according to priorities, logical connections between them, available resources and time schedules. It is like a map to travel safely trough unknown territory.

However, unlike perfectly researched maps that describe a well traveled region, projects designed to solve community problems are imperfect and easily fail in their objectives, result more costly or are subjected to harsh criticism. To help alleviate these shortcomings, strategic planning is an interesting tool, as it is designed to consider alternatives, to examine weakness and risks, to take into account strengths and opportunities. In this way, the minds are open to options and to flow with the necessary changes once the project is on the way.

When doing strategic planning, every thing can be considered from two sets of view points. The first set takes a look to a given situation and ask four questions:

- What are the strengths associated to it?
- What are the opportunities associated to it?
- What are the risks associated with it?
- What are the weaknesses associated with it?

These four questions correspond to the classical SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats).

The second set of view points examines the situation in relationship to its state, taking the best possible look to four states:

- The state of the art, which describes how the situation is handled in places or with methods known for quality, evolution and development.
- The ideal or theoretical state, which describes the limits that can be reached when the situation is taken to reversible and near perfect situation.
- The historical state, which describes the situation as it is and as it has been in previous times. This includes the measured and observed state which examines the situation through real observations made with experimental and auditing methods.

- The modeled state, which subjects the situation to simulations and probes, through different simulation techniques, in order to examine how it responds to possible variations.

This four state analysis will be called here STATE analysis. This eight view point examination illuminates the analysis of the situation and permits wiser project formulations. This eight view point exam belongs to a family of view points and analysis techniques that can be used in strategic planning:

- SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats)
- PEST analysis (Political, Economic, Social, and Technological analysis)
- STEER analysis (Socio-cultural, Technological, Economic, Ecological, and Regulatory factors)
- EPISTEL (Environment, Political, Information, Social, Technological, Economic and Legal).

The three last sets of this list correspond in some ways to STATE analysis which proposed here.

## 4. A simple example of strategic planning

Let us consider a simple situation and let us subject it to strategic planning. What to do in our house with the waste generated by daily family life. We propose this exercise as the initial point of any real strategic analysis of alternatives for waste management in a city. As far as we know, it has not has been done so far with the participation of a representative number of households and, not surprisingly, there is a lack of awareness in most people about how to deal with this situation in a responsible way.

The following matrix performs a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) to this situation

| **Strengths** | **Opportunities** |
|---|---|
| Available spaces to handle waste, such as yards, basements, cellars and gardens. | A family solid waste project could unite the family |
| Education and knowledge | Savings by recycling and rationalization of consumption habits |
| Creativity | Cleaner spaces and better habits |
| Consciousness | Better communication through eating and acting together and interacting |
| Family structure and civic beliefs and sense of compromise | Better education of children through real life examples |
| Small size | Acquiring a sense of pride and self esteem |
| Relationships with neighbors and friends | New methods could be discovered and shared with friends and neighbors |
| Free time | Community projects could be developed to better barrios and neighborhoods |
| Surplus money and savings available for small and reasonable projects | Organic fertilizers and materials could be developed to improve gardens and save money |
| Funds and support available for projects at the family and community level | The city waste load and waste handling cost could diminish |
| Existence of community groups and associations | |
| Existence of support from waste handling and municipal authorities | |

| Weaknesses | Threats |
|---|---|
| Lack of communications<br>Lack of vision and family purposes<br>Distractions and lack of time to share and work together as a family<br>Poverty and lack of means<br>Cynic beliefs and pessimism about civic values<br>Fixed ideas<br>Lack of awareness about the environment and about the importance of resources and of good housekeeping<br>Lack of time<br>Lack of leadership<br>Lack of knowledge about what to do<br>Lack of compromise | Projects could fail and cause discouragement<br>Family projects and community ideas could fail because of lack of municipal support<br>Public health risks when waste is mishandled at the household or neighborhood level<br>Projects could be discouraged by waste collection practices and regulations<br>Disputes and opposition of neighbors to recycling and to communal practices for waste handling<br>Projects could be abandoned for lack of vision, for practical difficulties or for lack of means<br>Presence of molds, bugs and animals attracted by poorly handled waste |

The following is a proposed STATE analysis, described in a colloquial and somewhat poetic and literary way.

**The state of the art in household waste handling**

I researched and researched looking for the perfect house,
in which mother and father and children worked together
to protect the earth from the themselves that throw things away.
to learn from each other and also teach things away.

I then saw this mother of three who prepared food lovingly
and invited all together to the common table to share and to eat with humble passion,
so that not leftovers, ever, were left,
and only prayers and good humor were thrown away every day.

I then visited their simple garden, a little space of flowers and essences,
where the children learned that nature can be created by men
where they learned to perform the miracles of composting
and witnessed the good ways of the earth worm.

Of course there were things that were discarded and that had a bad smell,
and useless plastics and bags, plus disposable vases and dishes,
dirty napkins, toilet paper, all the trappings that make easy modern life,
but they somewhat managed to handle that in ways surprising and wise.

To begin with, there were few of these things, and well classified and separated,
in clean tidy places well marked and adorned with colors and drawings,
so that when they went back to the cycle of life, dead or alive,
nobody received them with contempt, but with affability and gratitude.

Unfortunately I must tell that this special place only exists in dreams.
However, I am working on it, little by little and it is coming,
as you, reader will feel the challenge and take care,
as you, men and women of households will willingly dare.

**The ideal state**

The following list (table 1) describes ideal situations for several kinds of household generated waste. The reader should compare it to his or her own case and add new possibilities. Cities should prepare ideal models of behavior with the help of committed families and persons, so that citizens see clearly se how they can contribute to the diminishing of the waste load to be handled by the cities.

**The historical state**

Yesterday I was walking in my neighborhood observing waste handling, and this was what I saw. First of all, my city is known as the city of flowers, but there were vey few flowers on the windows of the houses and I saw no pots with flowers in the sidewalks of the streets. Almost everything was quite gray and covered with dull cement. Most sidewalks were clean, because the humble ladies and men employed by the cleaning authorities just passed by and cleaned the cumulated debris, as shown by the black plastic bags packed with waste and piled by the streets, waiting for the municipal truck to pick them to be taken to the dumping site, forty kilometers away. I saw some people putting domestic waste bags on the sidewalks, mostly used plastic supermarket bags full of mixed refuse, some loose, some closed. Some of the materials spilled from the bags, and I though that streets dogs could cause a mess, but, luckily, I did no see any.
Then I saw this lady, carrying some bags with her, the lady of the recycling. She and some men of her kind, walked by the streets, opening some of the bags, here and there, taking some plastic bottles, cardboards, paper and, from time to time, a piece of metal. They were careful, but some almost unavoidable spilling occurred. I felt uneasy, because I like clean streets and clean sidewalks, but did nothing about that. Then the waste truck came. A big truck, imported from USA, somewhat noisy and imposing. It made its way through the cars parked and running, unbelievably finding enough space to pass. Two men walked with it, picking the bags and throwing them inside. Some of the bags exploded when the mechanism pushed them in and I saw one of the men receiving drops of smelly liquids in his face coming from one exploding bag. Some twenty meters away, there was a little park and several open waste bags piled in front, with two gallinazo vultures pecking the bags, looking for some hidden manjar. The workers had to frighten them to take the bags to the truck.
In one of the houses, just in front, a young woman was sweeping from the inside of the house to the sidewalk, but it was not too terrible, only some dust. I also saw a car driver pass by and throw a cigarette butt on the street. This attracted my attention to the many butts on the floor. Then, the rain came. It was one of those tropical sudden rains that cause rivers of water on the streets. Luckily, I was near a covered sidewalk, in a bus stop, and waited there until the rain stopped. The water in the streets began to flow, dragging all kinds of things: leaves, bags, plastic cups. The things, really not too many, were however enough to cover the grate of the nearby culvert which made the entering water jump and I had to move so that my feet did not get wet. Then the rain stopped and I went back to normal life, away from the waste truck, to go on, although a little more aware of the people that have to pick the waste we do not know how to handle yet. I promised my self to do something. I started by writing this little story.

| Kinds of waste | Proposed ideal handling situation |
|---|---|
| General | Minimizing waste and good handling practices:<br>• Separate waste and keep it in several marked clean, covered and separated recipients to maximize opportunities for use and treating.<br>• Support good practices with the neighbors and participate in communal waste handling projects.<br>• Minimize waste through good buying habits.<br>• Stimulate simplicity, prudence and avoid habits of excessive materialism and waste.<br>• Keep some simple registers of amounts of waste, from time to time, seeking waste generating minimizing goals.<br>• Be aware of city programs to minimize and recycle waste and support them with words and behavior. |
| Food leftovers | Not leftovers resulting due to good cooking practices and good eating table practices:<br>• Loving cooking which takes into account people habits and health.<br>• Family table ways that encourage communal servings from food sources and only taking what can be eaten, without squandering the food<br>• Not eating in TV rooms or bedrooms.<br>• Good buying and storing practices to avoid food to spoil.<br>• Good eating habits to avoid excess weight or eating disorders |
| Organic leftovers resulting from vegetables and plants | Minimizing leftovers through good buying and cooking practices.<br>Collecting them in several marked clean, covered and separated recipients to maximize opportunities for use and treat.<br>Aerobic composting for use in house and community gardens.<br>Look for the city to develop systems to process separated organic waste to generate electricity or agricultural products. |
| Garden waste and cuttings | Establish some kind of aerobic composting system to use all the materials generated.<br>Do not burn or throw away materials |
| Plastics, glass, paper and metals | Make sure all materials of this kind are recyclable<br>Know the kinds and separate and keep them correctly and make sure they are handled to somebody dedicated to recycling or properly treating them<br>Get acquainted with persons and groups dedicated to handling these materials and support them<br>Use the municipal facilities available for recycling and contribute to their cleanness and good use |
| Used clothing, apparel, furniture and books | Share used items with friends, relatives and neighbors.<br>Get acquainted with persons and groups dedicated to handling these materials and support them.<br>Do not accumulate items without need |

Table 1. Ideal household waste handling situations

**The modeled state**

As it fits to an engineer, its is nice to calculate things and design small and simple models to determine what will be the effect of several actions, in this case, ones that a citizen could perform, for the benefit of the waste handling problem of a city. Two lines of actions were simulated, as follows:

- Keep doing what it is currently being done.
- Starting to work and influence people: Give lectures on good practices to minimize and handle waste; change the behavior in the house and in work to a perfect behavior as proposed in the idea state analysis; Get involved in projects related to waste problems.

The model is designed in a simple way, as described by the following graphs and tables. It was applied for a range of 20 years for a population of 1.000.000 people.

| Variable | Units | Range |
|---|---|---|
| Cost of land fill disposition and residue recollection | US $/ton handled | 15 – 42 |
| Value saved by recycling material | US $/ton recycled | 25 – 70 |
| Quantity of waste produced daily (initial) | Kg/person | 0,80 |
| Persons that are influenced by direct action (Primary influence factor on people) | Persons per year | 0 – 500 |
| Persons that are influenced by indirect action through primary influences (Secondary influence factor on people) | Persons per year | 0 – 50 |
| Factor of yearly change in patterns of residue generation (1.0 means no change) followed by influenced people | | 0,1 - 1,0 |
| Factor of yearly change in patterns of recycling (1.0 means no change) followed by influenced people | | 1,0 - 2,0 |

Table 2. Variables used for simple model of the effect of personal actions

Figures 1, 2 and 3 show the general behaviour of costs under several suppositions related to recycling rates, disposition costs and recovery costs due to recycling.

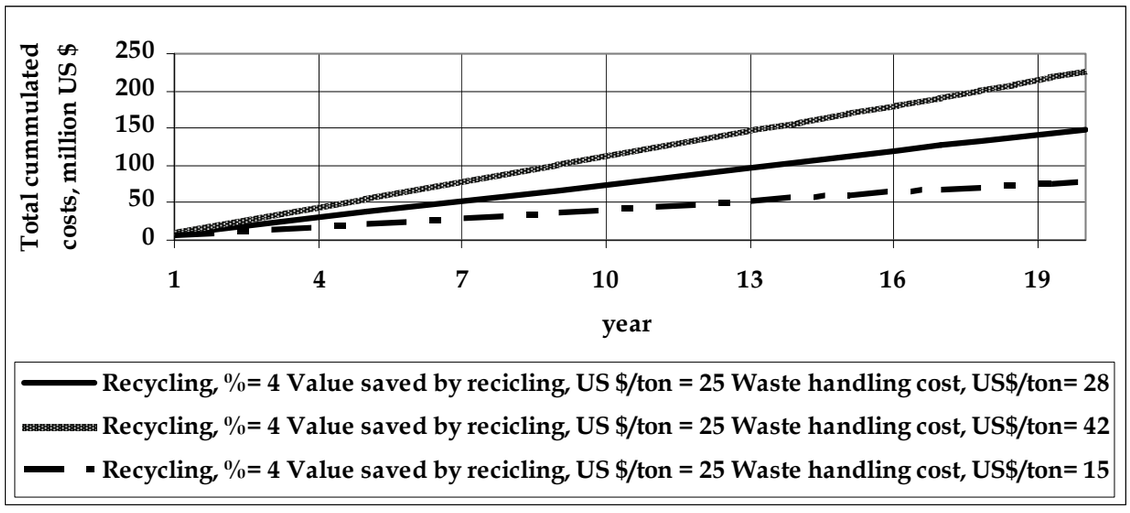


Fig. 1. Total accumulated costs at various waste handling costs

They allow having a general sense of the situation, which is quite useful when modelling something complex. Figure 1 shows that waste handling costs have a very large direct influence in the analysis.

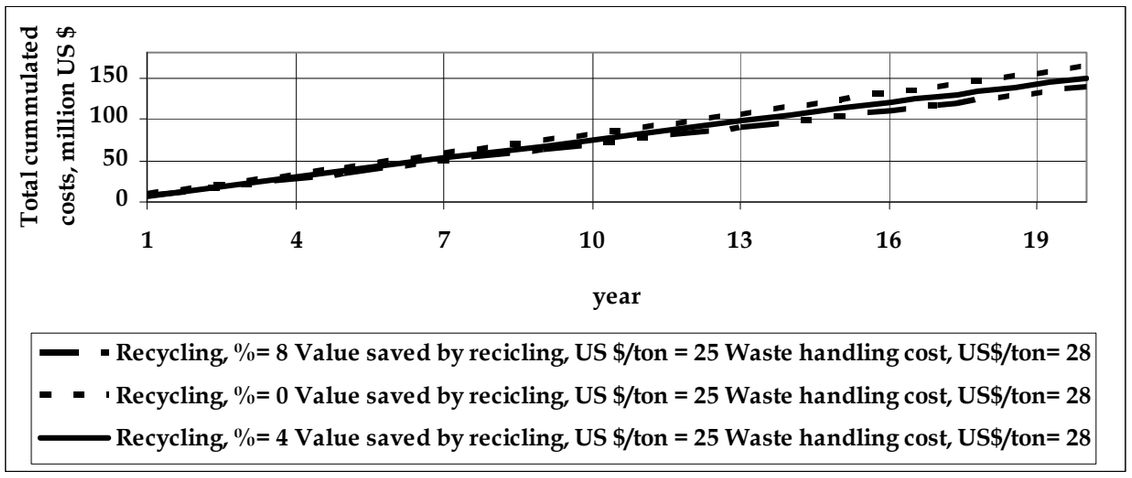


Fig. 2. Total accumulated costs at various recycling rates

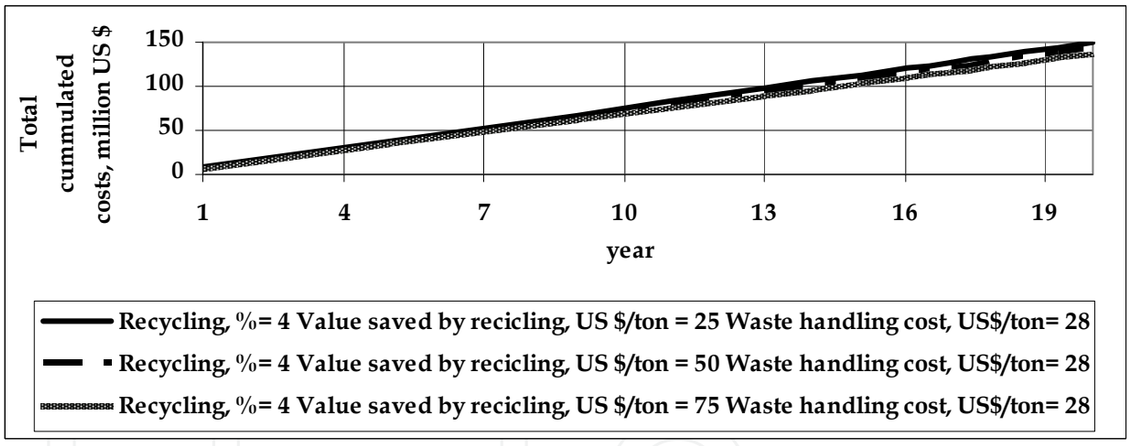


Fig. 3. Total accumulated costs at various values saved by recycling

Non-dimensional analysis is an excellent tool to understand situations in a more general way, as shown by figure 4. It shows that increased recycling and increased added value of recycled materials will mean a powerful combination to save money in the waste handling problem.

Now the model will simulate the effect of the actions taken to influence people, so that the influenced persons will do two things: change their patterns of residue generation for the good (less generation) and help change the recycling patterns with their influences. But also by having a secondary influence in other people (no tertiary influences were considered).

Figures 5 to 9 show the results of these simulations. They show that influences can be very powerful, especially when they are directed to change residue generation patterns. The percentage influenced can be very large if the actions are able to reach 500 people every year and if each of them influences also 50 other people. In this way in 20 years the influences will reach 51 % of the total population. This scenery, of course, is quite optimistic, but no

impossible, as shown by the effect of people like Rachel Carson. A more probable influence will be that of 200 direct influences per year with 20 secondary ones.

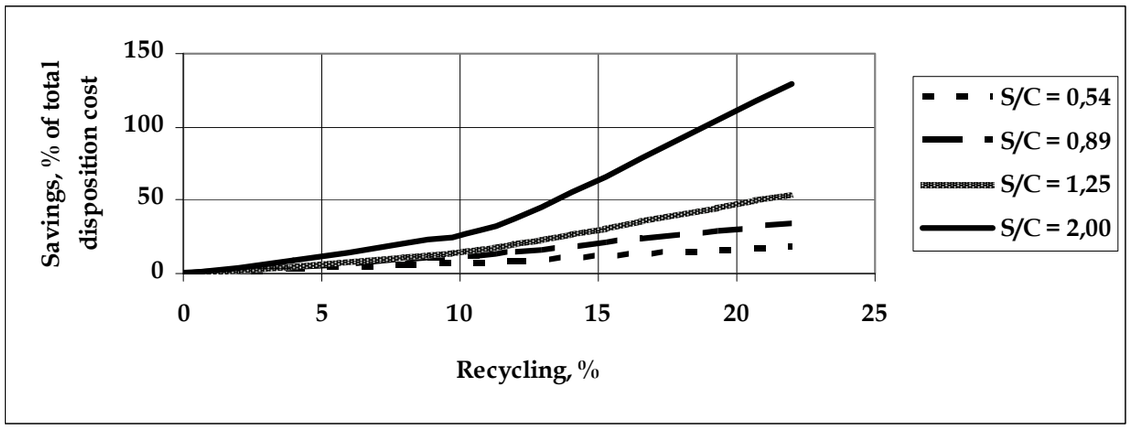


Fig. 4. Savings (Percentage) of disposal costs) as function of recycling rates for various ratios of value saved by recycling (S) to waste disposal costs (C)

| | | | | | |
|---|---|---|---|---|---|
| Primary influence factor on people | Persons per year | 0 | 500 | 200 | 200 |
| Secondary influence factor on people | Personas per year | 0 | 50 | 20 | 20 |
| Percentage of population participating under primary and secondary influence after 20 years | | 0,0 | 51,0 | 8,4 | 8,4 |
| Factor of yearly change in patterns of residue generation | | 1,00 | 0,95 | 0,10 | 1,00 |
| Factor of yearly change in patterns of recycling | | 1,00 | 1,25 | 1,00 | 2,00 |
| Cost of land fill disposition and recollection | Million US $ | 155 | 151 | 148 | 154 |
| Net cost after 20 years | Million US $ | 149 | 145 | 142 | 148 |
| Value saved by recycling after 20 years | Million US $ | 5,76 | 6,26 | 5,50 | 6,07 |
| Recycling initial | % | 4,00 | 4,00 | 4,00 | 4,00 |
| Savings initial | % | 3,86 | 3,86 | 3,86 | 3,86 |
| Recycling after 20 years | % | 4,00 | 4,44 | 4,00 | 4,22 |
| Savings after 20 years | % | 3,86 | 4,33 | 3,86 | 4,09 |
| Savings versus no action | Million US $ | 0,00 | 4,314 | 6,708 | 0,665 |
| Resulting change in recycling patterns after 20 years | % | 0,00 | 10,97 | 0,00 | 5,44 |
| Quantity of waste produced daily per person after 20 years | Kg | 0,80 | 0,77 | 0,74 | 0,80 |
| Resulting change in generating patterns after 20 years | % | 0,00 | 4,01 | 7,61 | 0,00 |

Table 3. Example of results of simple model of the effect of personal actions

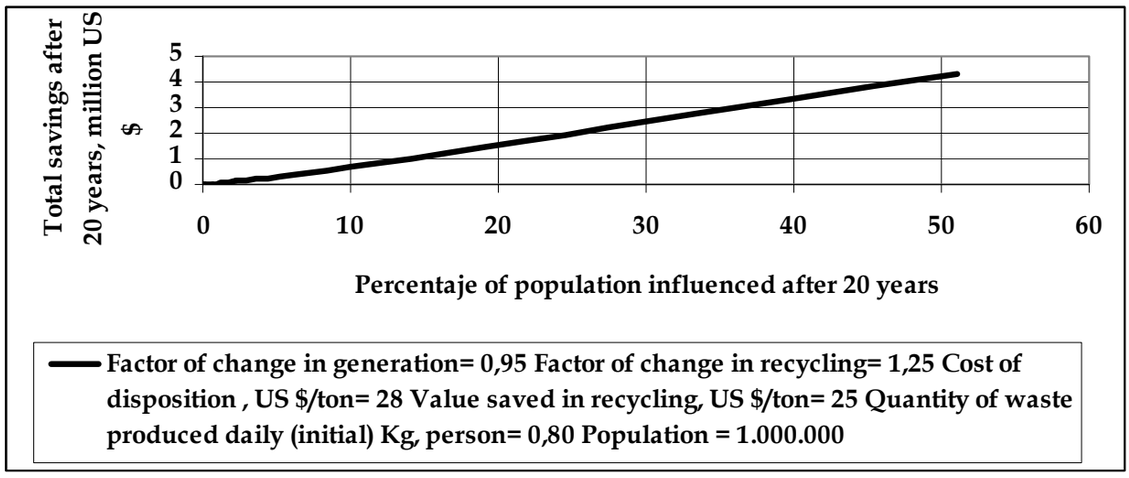


Fig. 5. Savings as a result of influences in population behaviour

Savings could reach significant values of the order of several US $ million dollars for the case simulated. This calls for the importance of cities to consider stimulating individual actions.

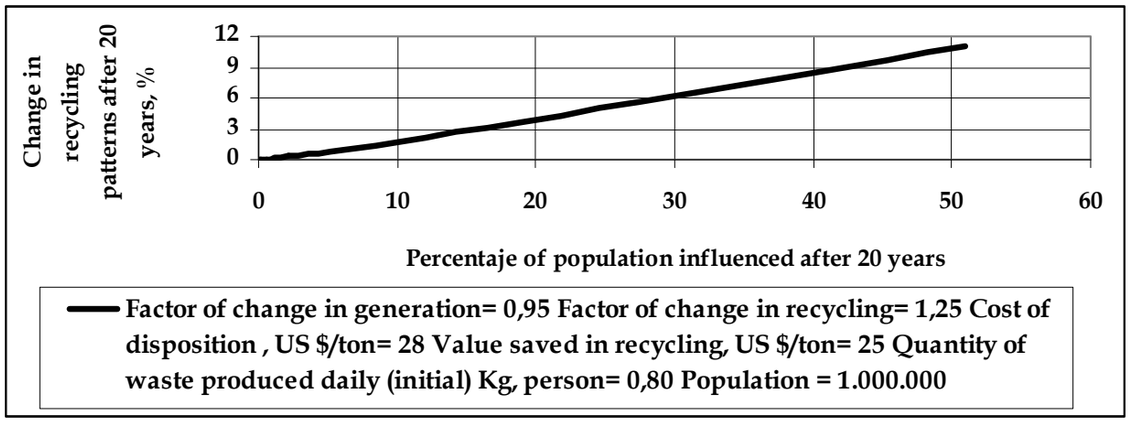


Fig. 6. Change in recycling patterns as a result of influences

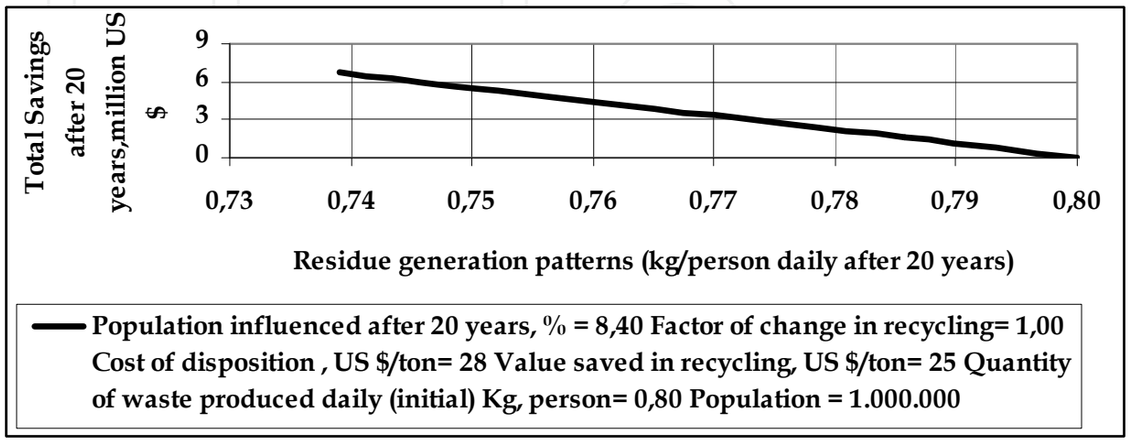


Fig. 7. Effect of the generation rate on total savings

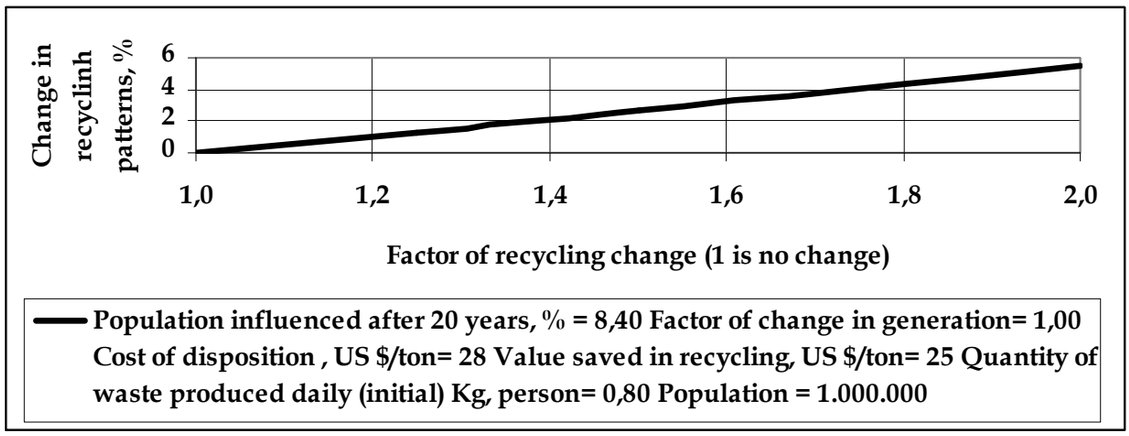


Fig. 8. Effect of the factor of recycling change on the variations of recycling rates

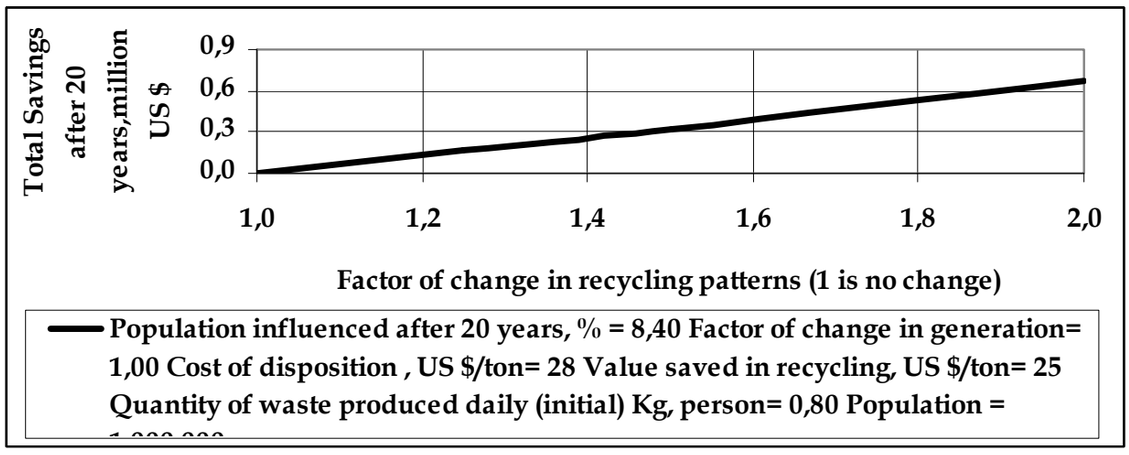


Fig. 9. Effect of the factor of recycling change on the total savings after 20 years

It is concluded that strategic analysis permits to observe the effect of alternatives and actions in a simple and powerful way.

## 5. The role of ideas and beliefs in the shaping of public policy

Creativity should be a major tool to resolve environmental issues, especially when dealing with recycling, recovery and re-integration. Major obstacles to go in the right direction are related to fixed ideas in the minds of people. Ten principles of creativity are now presented which have the potential to awaken people and to open their minds towards right actions and positive attitudes. Practical ways of application are suggested

**The need for a creative approach and where to find it**

These basic principles of applied creativity can be discovered and appreciated based upon one's intuition, personal experience, and studies. They possess great potentials that can be explored and, specifically in this case, can be applied to the development of creativity in the recovery and recycling of by-products and waste. When pondering these subject matters, it is helpful to first see oneself as an ethically responsible creator of new realities and, in this

particular case, as an author of the reality of sustainable development; then, these principles can be successfully applied.

**The "no-locality" principle**

In the heart of all things there exists a spark, a sense of divinity. We become creative and effective when we discover our duties as creators inspired by our divine sparks. This principle might be applied by first declaring that things must not be labeled as good or bad, since everything has a value and a divine spark, which is non-local and non-limited. A contaminant, a by-product, or a waste is a substance waiting to be correctly labeled as a source of opportunities for changes that could be translated into benefits. This leads to the idea of considering the controlling of environmental pollution, and the recovery and recycling as profitable and attractive processes. Such vision will facilitate the optimization of industrial processes, making them more profitable and less expensive as fewer by-products are generated. This will also allow for savings in materials and energy, less but better maintenance, and increased personnel commitment with better sense of belonging to the organization. Therefore, the challenge is to find the hidden benefit in any environmental handling by discovering the "good" zone that exists in any "bad" process and turning a threat into an opportunity.

**The "participation of the observer" principle**

The enormous wealth of our ecosystems provides an opportunity for discovering new ways of living together with active community participation. We are part of a lively laboratory of complexity, in whose foundation the secrets of life vibrate. Everything we discover is deeply influenced by the motivation that leads us into investigating a given situation. In other words, the observer creates the “reality”. Correspondingly, we can reach a sustainable future if we focus on a creative vision.

With our participation, we can create local industries and establish teams dedicated to waste cleaning and to the recovery and recycle of by-products. In this way, the quality of life for the poor people dedicated to the humble tasks of recycling waste can be notably improved. New uses for garbage, concurrent with new ways of diminishing and cleaning it, can be found through teamwork and common interest.

**The “uncertainty” principle**

It is not possible for facts or aspects of a given situation to be completely true. Life is an indeterminate work in progress. In the absence of certainty, a favorable change is always possible. Handling the relations with the workers with love and openness, so that they feel stimulated to contribute with useful ideas to the recovery, minimization, and recycling of waste. Learning to hear the complaints from the community in order to see them as opportunities for improvement, for growth and for development of new technologies, instead of seeing them as insurmountable misfortunes or nasty products of the production system. Visualizing laws and control rules as signs of alertness to changes and adaptation to better and more efficient realities, as means for the communities to handle uncertainties.

**The “complementary vision" principle**

Knowing the existence of duality in all things liberates us from creating artificial limitations. This freedom makes responsibility possible. This is the principle of “duality”, or the “complementary vision”. It is the vision that accepts that there are many ways to solve a problem and that it is not necessary to judge or fix arbitrary limitations on things or persons.

Superior levels of consciousness are characterized by an ample vision of the reality, where different viewpoints abound. In this way, the observer should witness without criticizing and be convinced that everything complements itself in one way or another. It is always possible to improve; it is always possible to evolve and to optimize. What seems to be perfect and simple may have some not-so-good aspects. Discovering them is an important step to improvement. Cost-benefit and strategic analyses are valuable tools, as they allow to see the complementary aspects of the problems and their solutions. Forming working teams in the companies, at all levels, and also among different companies, is an excellent way to achieve harmonic and complementary work.

**The "unity" principle**

Everything in the Cosmos is inseparable. From the union of concepts, of bodies, of minds, of ideals, of efforts, of information, of all things, creativity arises. This principle suggests the idea of unity and of the possibility for discovering it. Unity can be attained through "feeling" things, people, ideas, and objects in general as close to oneself as possible. To do so, one takes any object (person, belief, concept, rule, problem) and puts oneself in the place of the object to feel what it might feel being so. By doing this, we can become intimate, compassionate, and close to any object in the entire creation. This is a miraculous and effective way to discover unity. Once one can "feel" a waste or a by-product, one will know what to do with it.

**The "parallel universe" principle**

There are several levels of reality. There are several levels of consciousness. This is a principle that opens the door to hidden realities, to the unknown side of things. It refers to revealing ourselves as beings with various levels of consciousness, which we could awaken in order to experience them and to enrich our activity.

When we envision and make declarations for a new reality, which are stated clearly in first person and in the present time, creative energy comes unbounded and applicable, resulting in profitable and interesting ideas that arise ready to be developed. This creative state can be attained after following the steps described below (which are basically tools of strategic analysis):

- We identify a problem to be solved and define it clearly.
- We declare explicitly a target that identifies the envisioned solution. This is done at both personal and group level.
- We elaborate a personal, or group, declaration that is clearly stated in present tense and in first person.
- We move on to propose and take actions, with the certainty that there are going to appear synergies, help from others, new ideas and proposals that will line up in the direction of the sought target.
- We stay alert and ready to apply and stimulate those synergies, ideas and proposals.

**The "relativity of time" principle**

The limited and linear concept that we have assigned to time prevents us from seeing the Universe at a glimpse. Because of this, we only learn little by little. Life is more beautiful when we understand the eternal present at all times. Here we can find tools to handle one of our biggest limitations: our beliefs that we have not time, that we cannot change things, and that dead-lines are fixed. With these constraints, we tend to feel harassed and easily

give up. We tend to leave things to be done at the last minute, and avoid preparing and following timelines, thus lacking a global viewpoint. It is recommended to elaborate and continuously update lists with pending matters that need to be resolved. It is appropriate to estimate the necessary efforts required to find possible solutions to problems, in addition to their cost and benefits, so that later only those projects that turn out to be attractive are proposed.

It is important to have the mentality of insisting on the proposal of good ideas until they become practical. Projects should be managed on a budget, using timelines and with consideration of all possible feedbacks. Once a project is executed, consistent operation should be maintained until the awaited results materialize. The investment in human resources dedicated to the handling of waste minimization will lead to real and profitable projects. The establishment of a Research and Development department, with environmental responsibilities including process optimization, is profitable even in relatively small companies.

**The "energetic field" principle**

Life, nature, and all of us are a manifestation of an infinite energetic potential. We are part of an incessant flow of mass and energy. Obviously, there is space to explore the wide, almost unlimited, zones of energetic field in order to find new niches and creative contributions. But energy fields transcend and spread from what we know in the material realm to the totality of human realities, connecting all ways of consciousness in a mysterious way. For example, we have begun to know "technically" what we have always known from our hearts: that the forces of love exist, that they have physical effects, that solidarity, kind attention, and appreciation are the magic ways of composing reality. The establishment of networks of solidarity, the stimulation of cooperative systems, the support of public-spirit and of all the manifestations that enrich community work and brotherhood will be the sources of employment and happiness. Poverty, waste, and violence are the results of selfishness and lack of solidarity.

**The "entropy" principle**

Everything is in a process of either breakup or integration. Crisis contains the keys to development. Things agitate to change their level. From the apparent disorder, the miracle of dynamism and self-reference is born. We must not be afraid of change.

The creative handling of change and crisis has always been an opportunity to grow. This calls for a very special belief system, full of confidence in the capacity of people and society to respond. Leaders show their class in moments of change and crisis. The formation of leaders is an excellent investment for a society that wants to wake up. Leaders are beings that believe in their divine spark and in those of others, and they dare to get out of their average comfort zone. Without leaders, the society is left with chaos, unresolved conflicts, and negativity. This is "entropy in action". Waste and pollution are signs of entropy and lack of leadership.

**The "infinite underlying variety" principle**

There are powerful effects hidden in small changes that can influence reality. The chaotic order is a natural part of the existence. The reality is much more complex but, paradoxically, simpler than we believe. The celebration of complexity is the ceremony for initiation of teamwork. We are not forced to experience oppressive or fixed realities, since there are powerful effects hidden in small changes that can influence reality. Existence can always be

catalyzed and unexpected things can surge. This applies to wastes since they constitute realities that can be changed.

**The role of ideas in the developing of environmental awareness**

There was a great North American poet who gave rise to a literature current that opens consciousness towards nature: Henry David Thoreau. It began for him as a personal experiment. During two years, from 1845 to 1847, he lived deliberately, by his own means, in a natural zone, and that inspired him to write its classical poetic work, Walden, in 1854. Nature writing is one of the major innovations of American literature, which also includes Rachel Carson, the initiator of modern environmental awareness. Other significant figure is Ansel Adams, the American photographer and environmentalist, well known for his beautiful photographs of the American West and Yosemite National Park.
It is amazing how much the environmental movement owns to them and, at the same time, how little their subtle methods for consciousness development though images, poetry and inspired writing are employed in actual environmental activities. Illuminated by these great pioneers, whose knowledge of the living world, based on experience, was refined and projected as images, poetry and literature, people should take a look to the situation from a different perspective: to use poetry and images as a cradle to generate idea and attitudes, which in turn, will generate experiences.

**Two major levels of consciousness: A list of possibilities to experience and to understand nature and the world**

Human beings need an open mind in order to transform their present form of interpreting and experiencing nature, if we are to live in a sustainable civilization. This applies to everybody, as it is everybody who must participate in the necessary change, not only the illustrated elite that aligns with the environmental movement. These new viewpoints require a more complete and integral use of the entire nervous system, which will be able to integrate two necessary aspects: scientific observation and lyrical or poetic expressions.
The following table shows a list of two major possibilities to experience and to understand nature and the world. Both are important and necessary.

| Aspect | Logical | Poetic |
|---|---|---|
| Dominion | Mind - The conscious | Body - The unconscious |
| Perception | Thoughts – Sensations | Feelings – Intuition |
| Memory | Words - Numbers - Parts - Names | Images - Faces - Patterns - Global |
| Expression | Verbal – Oral – Counting - Writing | Nonverbal – Gesture - Drawing- Pothook |
| Thought | Analytical - Linear - Logical - Rational Sequential - Convergent | Visionary - Spatial - Analogical - Creative Simultaneous – Divergent |
| Action | Probing - Executing | Visualizing - Projecting |
| Organization | Norms – Capital - Resources | Vision - Values - Motivation |
| Definition | White and black – Sure - Assertive – Clear - Direct | Gray or colors - With alternatives - Suggestive and integrative – Indirect |

Table 4. Two major possibilities to experience and to understand nature and the world

## 6. A review of possible alternatives for solid waste handling

**The importance of good administration and sufficient human resources**

It could be that the entities responsible for waste managing in a given city, may have a lack of adequate technical administration and resources. It is important to count with sufficient human resources to focus on the appropriate technical handling of the solid waste. There is a tendency for these organizations to work mostly with independent contractors, lacking enough coherence and integration. Frequently the internal workload is too large for the few people who have technical responsibility and this gives rise to attention problems. It is important to have clear technical procedures, technical know how and human resources, continuity in the activities. It is important to have a clear capacity to plan, to study, to make tests and monitoring, to pursuit and develop ideas, to optimize the processes and to introduce changes, to respond to environmental authorities, to the communities and to mass media and to handle the contractors.

**The importance of internal planning**

As the solid waste problem is so complex and things are changing due to population variations, material variation, regulation changes and market forces, it is very important that the entities responsible for waste managing in a given city, have some kind of integral planning program. It could be that the organizations tend to act in reaction to daily pressures in the middle of many limitations. It is important to count with an integral approach based on goals, backed by enough dedicated personnel, monitored by management indicators, rich in good communications with the authorities and the community and instrumented with cost benefit analysis to rationalize costs.

**Integral planning model as a basis for strategic analysis**

A program of this type should be able to consider a complete set of alternatives, including the following situations:

- Program of education, separation in the source and recycling.
- Adequate collecting and transportation of waste
- Plant for recycling plastics, paper and metal.
- Electronic waste handling
- Organic waste handling, use and recovery
- Stations for waste handling
- Design, planning and administration of appropriate land fill sites and waste disposition facilities
- Handling of lixiviates
- Treating of biogases generated
- Thermal plant for recovering energy,
- Incinerating
- Design, planning and administration of appropriate land fill sites and waste disposition facilities

## 7. Modelling clues and helps

**Composition of waste and estimating value in a general way**

The composition of the waste is a very important strategic variable. And it is a variable in itself, because it changes in time and it will be distributed in different ways according to the

district considered. The table shows the "average" distribution for a large city in a developing country.

| Material | Percentage |
|---|---|
| Organic | 53,22 |
| Paper | 14,62 |
| Plastic | 10,51 |
| Glass | 4,87 |
| Cardboard | 3,14 |
| Textile | 3,00 |
| Construction rubbish | 2,89 |
| Metals | 1,86 |
| Bones | 1,37 |
| Leather | 0,80 |
| Other | 3,72 |
| Total | 100,00 |

Table 5. Considered weight distribution of municipal waste

Average values are used for general planning, but variations should be considered. Future general distributions will resemble the current distributions for more prosperous districts. Some kind of model should be drawn to understand the distribution within the city according to the economic status of the population in the different districts.

The composition should be looked at from the point of view of recycling and use of the materials. It is advised to give a value to the materials, to have in mind that they really are valuable items. The following table reflects this approach, for the weight distribution of table 5. This will help to vision the possibilities hidden in recycling schemes, as compared to just putting the materials in a land fill in a non discriminated and arbitrary way.

| Material | Estimated range of value, US $/kg | Average contribution to total value, $/kg total waste | Contribution to value, % |
|---|---|---|---|
| Organic | 0,01 - 0,10 | 0,029 | 15,58 |
| Paper | 0,025 - 0,25 | 0,020 | 10,70 |
| Plastic | 0,25 - 1,75 | 0,105 | 55,93 |
| Glass | 0,025 - 0,30 | 0,0079 | 4,21 |
| Cardboard | 0,025 - 1,50 | 0,0027 | 1,46 |
| Textile | 0,010 - 0,025 | 0,00053 | 0,28 |
| Construction rubbish | 0,005 - 0,015 | 0,00029 | 0,15 |
| Metals | 0,50 - 1,75 | 0,021 | 11,14 |
| Bones | 0,025 - 0,050 | 0,00051 | 0,27 |
| Leather | 0,010 - 0,025 | 0,00014 | 0,07 |
| Other | 0,005 - 0,015 | 0,00037 | 0,20 |
| Total | | 0,188 | 100,0 |

Table 6. Proposed method to value residues in a general way

**Collecting of waste**

This is a critical part of the strategic analysis. Garbage trucks are very expensive and collection routes complicated. Linear programming or a similar kind of technique should be used to better understand and plan the routes and the transportation needs. The following table shows a typical cost distribution for a waste truck, which usually account for more than the 50 % of the waste handling costs.

| | | |
|---|---|---|
| Fuel consumption | km/gal | 3,70 |
| Cost of fuel | US $/gal | 2,8 |
| Travel distance | km | 152 |
| Waste load | ton trip | 12 |
| Cost of fuel | US $/km | 0,76 |
| Cost of fuel | US $/ton | 9,58 |
| Filters and lubricants | % fuel | 20 |
| Filters and lubricants | US $/km | 0,15 |
| Filters and lubricants | US $/ton | 1,92 |
| Spare parts and maintenance | US $/km | 0,80 |
| Spare parts and maintenance | US $/ton | 10,13 |
| Tires | US $/km | 0,25 |
| Tires | US $/ton | 3,17 |
| Financing and depreciation | % monthly | 1,56 |
| Investment | US $ | 160.000 |
| Trips per truck monthly | | 25 |
| Financing and depreciation | US $/km | 0,65 |
| Financing and depreciation | US $/ton | 8,30 |
| Labor | hr/km | 0,158 |
| Labor | US $/hr | 4,5 |
| Labor | US $/km | 0,71 |
| Labor | US $/ton | 9,00 |
| Insurance and taxes | % monthly | 0,43 |
| Insurance and taxes | US $/km | 0,65 |
| Insurance and taxes | US $/ton | 2,29 |
| Total | US $/ton | 44,38 |

Table 7. Model for waste collection and transportation costs

**Economics of recycling**

Recycling has been a growing industry and could contribute greatly to create employment, a more sustainable use of resources and prosperity, if it is seen at from an integral point of view. In many cases, it is left to the spontaneous action of poor and unemployed citizens or to the operation of informal enterprises. Many of those people undertake recycling under hard conditions, without benefits or decent working environments.

Plastics, which as seen in table 6 are the more valuable resource in the waste basket of a city, can be recycled in many ways. Recycling units for plastic are commercial in the international market and could also be developed with local creativity, design, engineering and construction. It is important to create value with them, by manufacturing products. In this

way, prosperity and jobs will be created locally in a very responsible way. Of course it is fundamental to stimulate separation in the source, as compared to separation after the plastics are mixed and dirtied by the mixing, especially with organics. In order to visualize

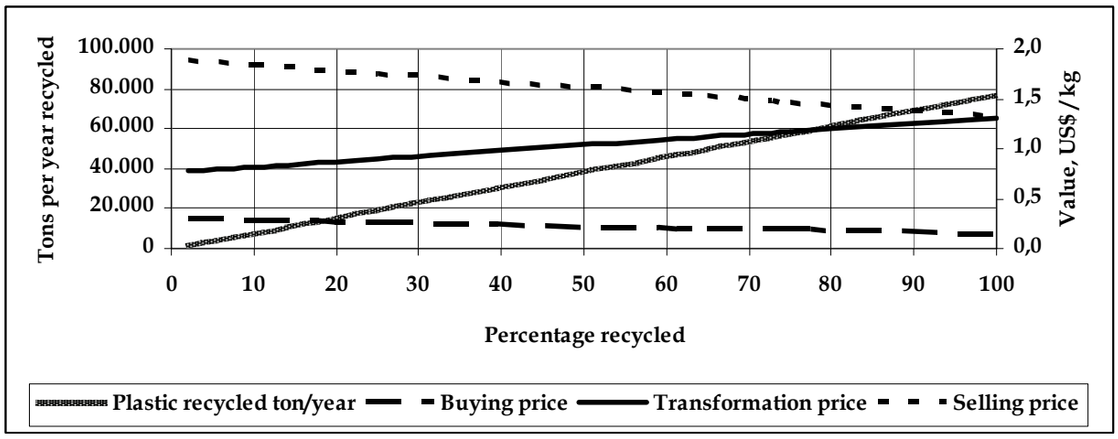


Fig. 10. Example of economics of a recycling scheme. Prices as function of recycling capacity

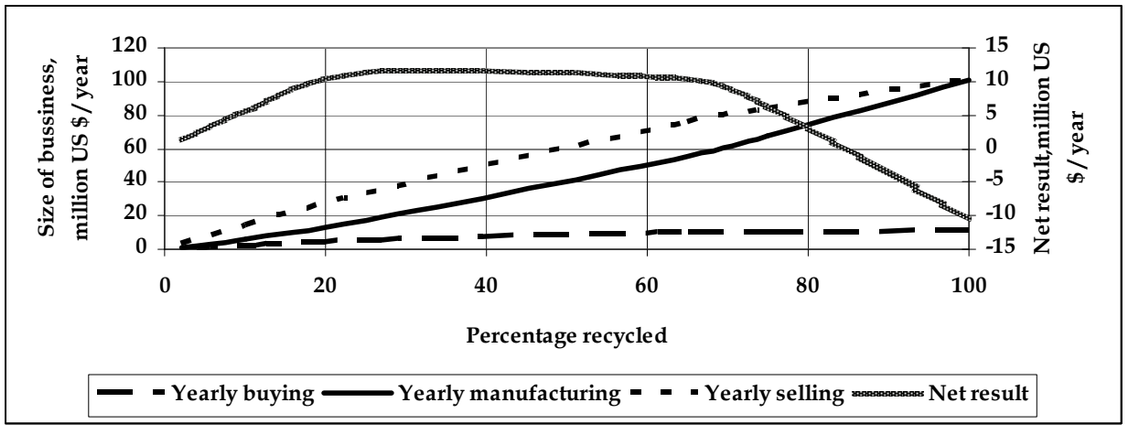


Fig. 11. Example of economics of a recycling scheme. Size of the business and recycling

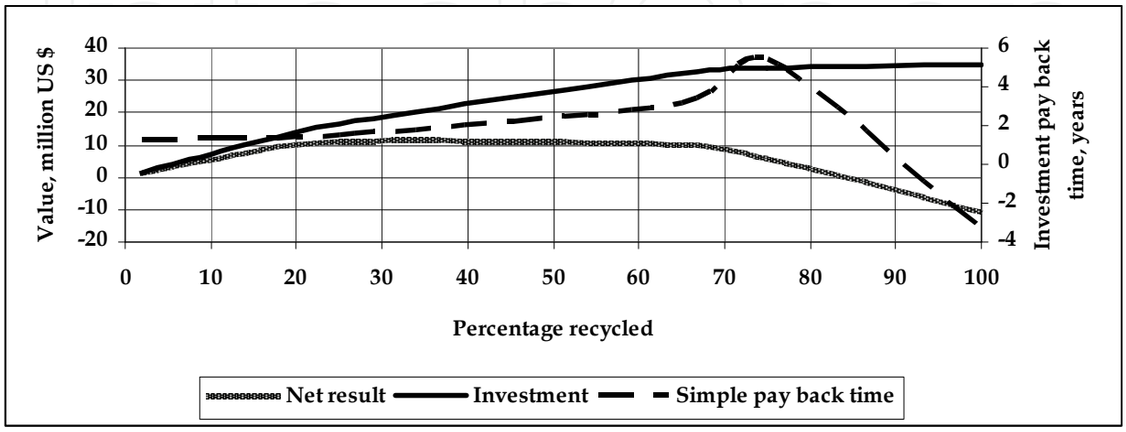


Fig. 12. Example of economics of a recycling scheme. Net results and pay back time.

opportunities, the following analysis, based in a real case of a production plant for recycling plastics and converting them to final products (plastic wood, pellets, bags) with a capacity of 14.256 ton/year and a new investment of 12,5 US million $ is shown in the next graphs. The analysis was made for a city producing 2.000 tons per day of waste, with 10,51 % in weight of plastics.

Schemes like the one shown can be applied to each resource available in the waste basket of the city. This is responsible planning, which will lead to actions.

It is very important to include electronic waste handling in the strategic analysis. The cities should negotiate some type of returning scheme with the companies that manufacture electronic items. A preferred alternative is to include local separation and added value facilities as part of the scheme, supported by the manufacturers.

**Organic waste handling, use and recovery**

It is mandatory to have a high level of consciousness and give special considerations to organic waste, especially for cities that generate high percentages of organic waste. Organic waste can be easily converted in valuable materials for agriculture use. However it is not the case in general. This is due to fixed beliefs systems that put the emphasis on the false easiness of mixing everything and put it away. The old countryside ways were lost entirely when people migrated from the rural areas to the cities and dumping everything to the garbage truck became a necessary modern feature. It is important to understand the values contained in the organics and to have several sceneries to simulate, for example:

- Schemes to stimulate good practices at households and separation of organics.
- Schemes for household and residential units recycling to make compost for use in gardens. Also larger schemes to process separated organics at landfill sites, especially material from institutional sources.
- Schemes to have special recollection of organics to be taken to processing facilities, both wet and dry, to generate biogas, electricity, agriculture materials and even new products, such as biogas, alcohol, hydrogen and biodiesel.

**Handling of lixiviates**

Lixiviates are going to be generated in any landfill facility as a result of the process undergone by the organics and the effect of rain. The following figure shows a real situation of a land fill site located in a place with very high precipitations (3.600 mm per year). The

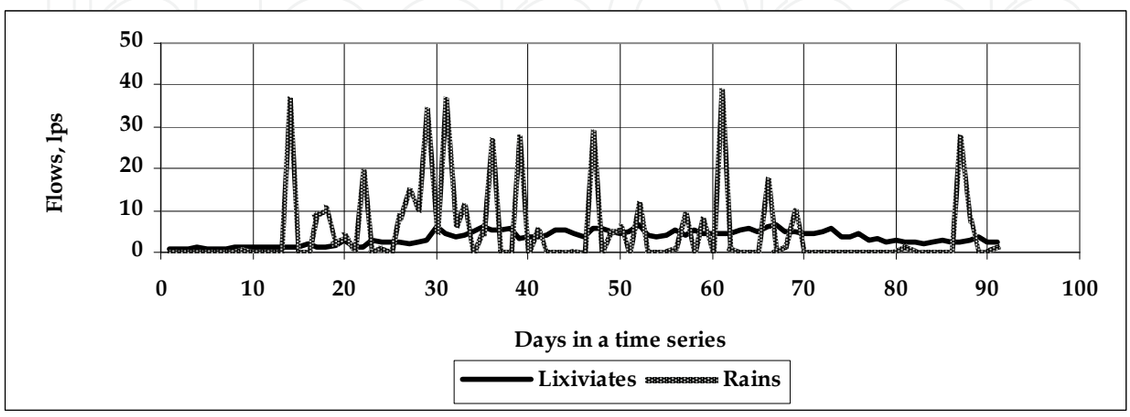


Fig. 13. Flows form lixiviates and rains in a landfill with high precipitation (3.600 mm)

rain was distributed on the land fill site area and the resulting flow is compared to the actual landfill lixiviates flow. Its is clear that rains will increase lixiviates and complicate the water treatment system for them, as water treatment plants have investments cost related to flow to be treated.

It is estimated that the flow of lixiviates coming form the process is caused basically by the organic materials deposited in the last 2,5 years in the landfill site. The contribution factor was estimated as 0.0041 litres per second (lps) per each 1.000 of organic ton of this nature. The flow of additional lixiviates coming from the effect of the rain is estimated with the following expression (where x is monthly rains in mm):

$$\text{Additional lixiviate flow from rains, lps} = \text{Area that allows drainage (has)}/5 * (0{,}00000832x^2 + 0{,}00430x + 0{,}54) \quad (1)$$

Lixiviates have to be treated. The investment in the treatment plant is important and may be in the range of 0.20 to 0.40 US million $ per each litre per second of lixiviates. The treatment cost as such could be in the range of 0.50 to 1.20 US $ per m3 of lixiviate.

**Biogases generated**

Biogases are generated also because of the organic nature of waste, under the effect of bacterial action. Biogas will tend to be a mixture of CO2, CH4 and humidity.

Biogas is a rich resource and can be used to generate electricity or heat or even hydrogen. However, this will depend of how strategic the decision of placing the landfill site was. If the site is far from the practical use of these applications, then the energy recovery costs will be too high and the gas will have to be burned to avoid green gases emissions without real gain. This sadly will happen because people tend to reject landfill sites, so they are placed far from the cities of industries. An alternative is to conceive the site as an industrial integrated unit able to generate added value in many ways, all of which will require energy and electricity. The recycling facilities that transform plastic in final products, for example, are large consumers of energy and can be close to the land fill site.

| Typical biogas composition (% volumetric wet) | |
|---|---|
| CH4 | 47,7 |
| CO2 | 29,6 |
| H2S | 2,4 |
| H2O | 20,0 |

Table 8. Typical landfill site biogas composition

Biogas annual emissions from organic deposits can be estimated using the expression (based on John Pecey 1975)

$$\text{Emissions (Nm3/min/ton organic)} = 0{,}0000986\ x^{-0{,}756} \quad (2)$$

Where x is the year counted from the initial placing of the organic material in the site. The behaviour is exponential and shows decreasing amounts of emissions. After 20 years the total emitted will be around 0.319 Nm3 per kg of organic waste. The high heat power contained in the biogas will around 4.240 Kcal/Nm3 of wet gas. About 25 to 35 % of this energy can be converted to electricity.

With this information estimates can be made of the biogas emissions and of the potential they have to generate electricity or heat.
To gather the biogas, wells should be placed and also a pipeline network. A rule of thumb is to place each one to collect 1.600 m2 of landfill terrain. Each well will handle around 60 Nm3 of wet biogas per hour, obviously depending on the real design of the landfill.

**Incineration**

This is a real possibility, because the waste contains important amounts of energy. Plastics, paper, cardboard, wood, textiles contain net heat power. Organic materials, being wet, do not contribute as much, although they also have energy potential when dried. Incineration has the advantage of reducing significantly the volume of waste to be disposed, as much of the mass become gases (mostly CO2 and water) and only the ashes stay solid, which will be less than 10 % of the initial matter. Also, it can be done in a compact facility, within the city limits, fulfilling all the environmental norms when well designed and operated. For these reasons many cities in Europe, Japan and USA have incineration facilities. However incineration is quite questioned nowadays because it destroys valuable materials such as plastics and contributes to green house effects.
Any strategic analysis should include incineration and an as complete as possible impact analysis should see the different sides of the situation.

## 7. A comparison of possible alternatives for solid waste handling

As an example of strategic analysis, a situation is presented, in which four different alternatives are studied. It applies to a city with three million people, situated in a developing country, generating some 2.000 tons per day of waste, that are taken mostly to a landfill site with only small percentages being subjected to recovery or recycling..

**Alternative 1, the present situation**

In this, there are no programs of recycling or separation in the source, undertaken directly by the organization in charge of waste handling, although some recycling and separation are under way done by low paid recyclers and some well organized cooperatives. At the time, a modest organic waste recovery program for elaborating compost was in place, which did not work. This alternative does not include a plant for treating lixiviates nor any systems to take advantage of the energy gases.

**Alternative 2, an improvement on the current situation**

It is an alternative that is thought to be reachable, but implies concerted efforts and intelligence of all the involved sectors, much conscience in the city, leadership in the organization and citizen commitment. It includes a plant of treatment for lixiviates, a thermal plant to take advantage of the energy of biogases, a rotary incinerator for special waste, increasing separation in the source and of recycling programs, with strong educative components and a more intense program of treatment of the organic wastes towards composting.

**Alternative 3, one more aggressive approach to recycling and separation**

It includes more demanding goals for recycling, treatment of organic and separation in the source, simultaneously with treatment of lixiviates and also using a thermal plant for recovering biogas energy and a rotary incinerator.

**Alternative 4, aggressive education and source management of waste**

It is a situation in which the emphasis is put mostly in recycling, treatment of organic waste and separation in the source and a lixiviate treatment plant is included. It does not consider thermal plant or incineration to take advantage of the biogas energy, which is simply burned. Investment in education and publicity is high.

**Results of the model**

| Alternative | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Situation | Actual | More recycling and biogas recovering | High recycling and high biogas recovery | Very high recycling and not biogas recovery |
| Waste recycling and separation | No | Medium | High | Very high |
| Lixiviate plant | No | Yes | Yes | Yes |
| Organic waste treatment | Very low | Medium | High | Very high |
| Thermal Plant | No | Yes | Yes | No |
| Incineration | No | Yes | Yes | No |
| **Waste generated and treated in 20 years (million tons)** | | | | |
| Total generated waste | 19,62 | 19,62 | 19,62 | 19,62 |
| Organic treated | 0,27 | 2,02 | 3,91 | 4,85 |
| Recycled or separated | | 1,90 | 3,53 | 4,23 |
| Incinerated | | 0,38 | 0,38 | |
| To be taken to the landfill site | 19,35 | 15,32 | 11,80 | 10,54 |
| **Other operation parameters** | | | | |
| Open area in the landfill site (hectares) in 20 years | 154 | 122 | 95 | 85 |
| Biogas energy flow (year 20), million Kcal/hr | 58 | 42 | 25 | 21 |
| Number of trips to the site (thousands) in 20 years | 0 | 1.962 | 1.771 | 1.608 |
| Directly Employed persons in the programs | 875 | 1.072 | 1.203 | 1.177 |
| Relative economics, % savings against actual situation | | 7,17 | 6,37 | 1,94 |

Table 9. General results for the four alternatives for a 20 year operation of the programs

It was observed that the alternatives 2, 3 and 4, that imply programs of separation in the source and treating in some way the waste, are more attractive from the economic point of view that the present situation. In spite of the apparently high investments, the alternatives that contemplate use of biogas are more attractive than those than do not use it. It is clear that this is not really an economical problem, but a problem of beliefs and attitudes.

It is important to note that the proposed alternatives, besides being more economical, show also a favourable impact on direct and indirect employment, which is very important for a city like the one studied, subject to difficult unemployment and social problems. These cities

have enormous potentials for growth and a real need for improving the quality of life for the people. It should focus correctly its solid waste problems. It has been shown that alternatives that attack the problem from an integral point of view are more attractive than the current situation. It is necessary that a city of this importance count with integral planning for handling this type of problems.

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**Waste Management**

Edited by Er Sunil Kumar

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Solid Waste Management is one of the essential obligatory functions of the Urban Local Bodies/Municipal Corporation. This service is falling too short of the desired level of efficiency and satisfaction resulting in problems of health, sanitation and environmental degradation. Due to lack of serious efforts by town/city authorities, garbage and its management has become a tenacious problem. Moreover, unsafe disposal of garbage and wastewater, coupled with poor hygiene, is creating opportunities for transmission of diseases. Solutions to problems of waste management are available. However, a general lack of awareness of the impact of unattended waste on people's health and lives, and the widespread perception that the solutions are not affordable have made communities and local authorities apathetic towards the problems. The aim of this Book is to bring together experiences reported from different geographical regions and local contexts. It consolidates the experiences of the experts from different geographical locations viz., Japan, Portugal, Columbia, Greece, India, Brazil, Chile, Australia and others.



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