Globalization, Megacities and Waste Management

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EXECUTIVE SUMMARY

The purpose of this paper is to present the challenge of waste management for the emerging megacities of the developing world and transition countries and to outline the necessity for new tools, based on complexity theory and complex systems' science in order to plan and deliver sustainable waste management systems in megacities.

Firstly, the triangle megacities – globalization – waste management is presented as a framework to understand the challenge of waste management in a megacity. The relations and interconnections between megacities & globalization, globalization & waste management and finally megacities & waste management are discussed in order to highlight crucial characteristics and the challenge of waste management in a megacity.

The analysis of the interconnections between megacities, globalization and waste management provides the basis for understanding waste management in a megacity using a complexity theory approach. The author suggests that due to megacities' particularities, any megacity's waste management system is a complex system, which means that complexity theory tools (Cellular automata, network analysis, and agent based models) are certainly useful for waste management purposes.

Concluding, the author calls for a new conceptual approach to waste management planning in megacities that will incorporate complexity theory and similar tools as a step towards a better understanding and management of megacities' problems.

INTRODUCTION

This paper is a result of the work that is elaborated under the ISWA project "Globalization and Waste Management". On July 2010 ISWA created a Task Force (TF) dedicated to address globalization and waste management as a key-issue for the waste management society worldwide. According the TF framework, informal sector issues, megacities, global recycling markets and international aid tools were considered as the most important issues affected by globalization. Although this paper focuses on megacities, some other findings of the TF work are presented too.

21st century is already characterized as the first Urban Century in the history of human species. After 2007, the majority of the human population is already concentrated in urban areas. According official reports (United Nations Population Division, 2005) by 2007, 3.2 billion people - a number larger than the entire global population of 1967- live in cities. From the 3 billion increase of the population expected until 2030-2040, 60-65% will be realized in urban and metropolitan areas. By 2050, an estimated two-thirds of the world's population will live in urban areas, imposing even more pressure on the space infrastructure and resources of cities, leading to social disintegration and horrific urban poverty.

Megacities are a product of the continuous urbanization process. A megacity is usually defined as a metropolitan area with a total population in excess of 10 million people. Megacities can be distinguished from global cities by their rapid growth, new forms of spatial population density, and both formal and informal economy, as well as poverty, crime, and high levels of social fragmentation. A megacity can be a single metropolitan area or two or more metropolitan areas that converge.

The number of megacities is increasing (UNFPA, 2007) worldwide: 1950: 2, 1975: 4, 2003: 21. By 2015, there will be 33 mega-cities, 27 of them in the developing world. Two third of them are situated in developing countries, especially in South-East-Asia. In 2003 already 283 million people lived in megacities, 207 million of them in developing countries, more than 171 million in Asia.

Megacities population is estimated to increase by 280.000 people per day (UNFPA, 2007)! In the year 2015 the total population of megacities worldwide (Cohen, 2006) will be about 359 million and the future rate of growth will be high, as the development of Jakarta, Delhi, Dhaka and Karachi have shown. Their population tripled between 1975 and 2003. According UN estimation (United Nations Population Division, 2005) concerning the number of megacities in 2015, Tokyo (36.2 mill. inhabitants), Bombay (22.6), Delhi (20.9), Mexico City (20.4) and São Paulo (20.0) will be the worldwide five biggest megacities each with much more than 20 million inhabitants.

Although cities themselves occupy only two percent of the world's land, they have a major environmental impact on a much wider area. Mega-cities are likely to be a drain on the Earth's dwindling resources, while contributing mightily to environmental degradation themselves. Megacities face tremendous environmental challenges and threats for human health. In this framework the role of waste management is becoming more and more crucial both for the daily life as well as for the long to medium term sustainability of megacities. The challenge of a successful waste management in megacities is one of the most demanding for human societies and especially for the waste management industry.

Before going in further details, it is mentioned that this paper adopts the framework if Integrated Sustainable Waste Management (ISWM) as it is presented in different papers (Anschutz, 2004, Cointreau, 2001, IJosse 2004). In a simplified way the concept can be represented by the two triangles (Hardware and Software) of Fig. 1

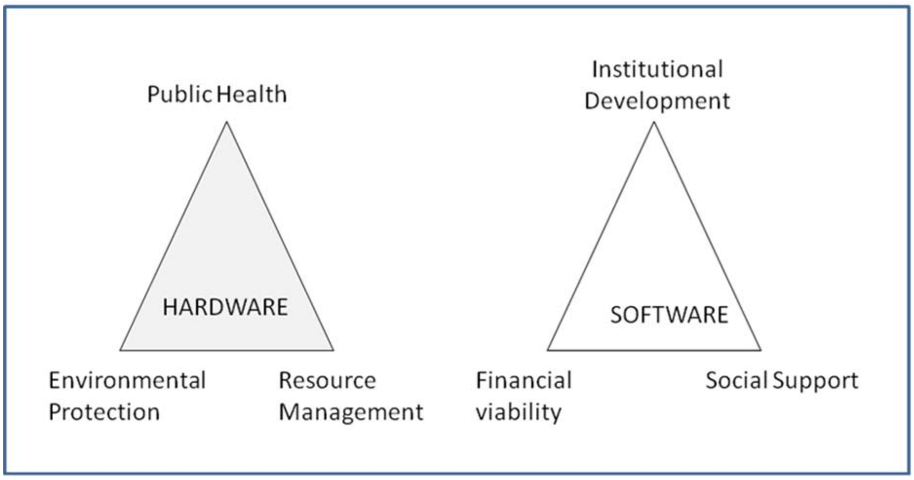

Fig. 1: ISWM simplified concepts

Perhaps the most important characteristic of the ISWM concept is that it demonstrates that a city performance in waste management results (exactly like a PC performance) from the holistic emerging behaviour of the Hardware combined with the right Software. No matter how good is the Software, few or even no results will be delivered if the Hardware is problematic and vice-versa.

MEGACITIES AND GLOBALIZATION

Cities are the basic theatres, in which globalisation stages its actions. As a result globalisation brings opportunities for several cities, especially those that can be key centres for production, distribution and services for liberalising economies, including megacities.

Megacities are increasingly becoming the interface of a country with the globalised economy and culture, rather than being closely connected to the surrounding rural hinterland as was often the case in the past. They are hubs in super-national complexes in several ways (GlobeScan, 2008, Bronwen, 2006, Kötter, 2008) in terms of water, energy, waste and material fluxes, as well as in terms of socio-economic and political developments, and environmental and security considerations. In that way, megacities are also part of the global trade of recyclables and the illegal waste trafficking network.

Megacities are also foci of global risk (Earth Science for Society, 2005). They are increasingly vulnerable systems because they often harbour pronounced poverty, social inequality and environmental degradation, all of which are linked together by a complex system supplying goods and services. Megacities are particularly vulnerable to natural disasters because (Wisner, 2003) their scale and geographic complexity make it difficult to provide the lifeline and transportation infrastructure necessary for risk reduction. Many mega-cities are usually located in geographically hazardous locations such as coastal areas or seismically active zones, making them susceptible to floods, windstorms, wild fires, earthquakes, tsunamis, and volcanoes.

For all those reasons megacities have been characterized as Global Risk Areas (Kraas, 2003) for both natural and man-made hazards, including the health problems that might be created by inappropriate waste management systems. In this view, the importance of health problems that are related with waste management is becoming of global interest. It has been mentioned (Leautier, 2006) that demands for city infrastructure in the context of globalization might generate local - global conflicts that require new institutions for solutions.

GLOBALIZATION AND WASTE MANAGEMENT

Globalisation brings with it potentially large benefits as well as risks. Globalisation's dynamics offer many opportunities to improve the human condition, but also involve significant potential threats. The challenge is to manage the process of globalisation in such a way that it promotes environmental sustainability and equitable human development. All those remarks are true for the relation between waste management and globalisation.

The author's view is that there are two way linkages between globalisation and waste management: not only does globalisation influence and change waste management practices (such as the worldwide spread of recycling and waste prevention) but also waste management practices affect the way globalisation progresses (e.g. establishing global recycling markets, waste trafficking).

Besides urbanization, which has resulted in the creation of megacities, it seems that the major domains of interaction between globalisation and waste management can be directly related with the changes that globalisation brought to (see Fig.2):

- Economy
- Knowledge
- Governance

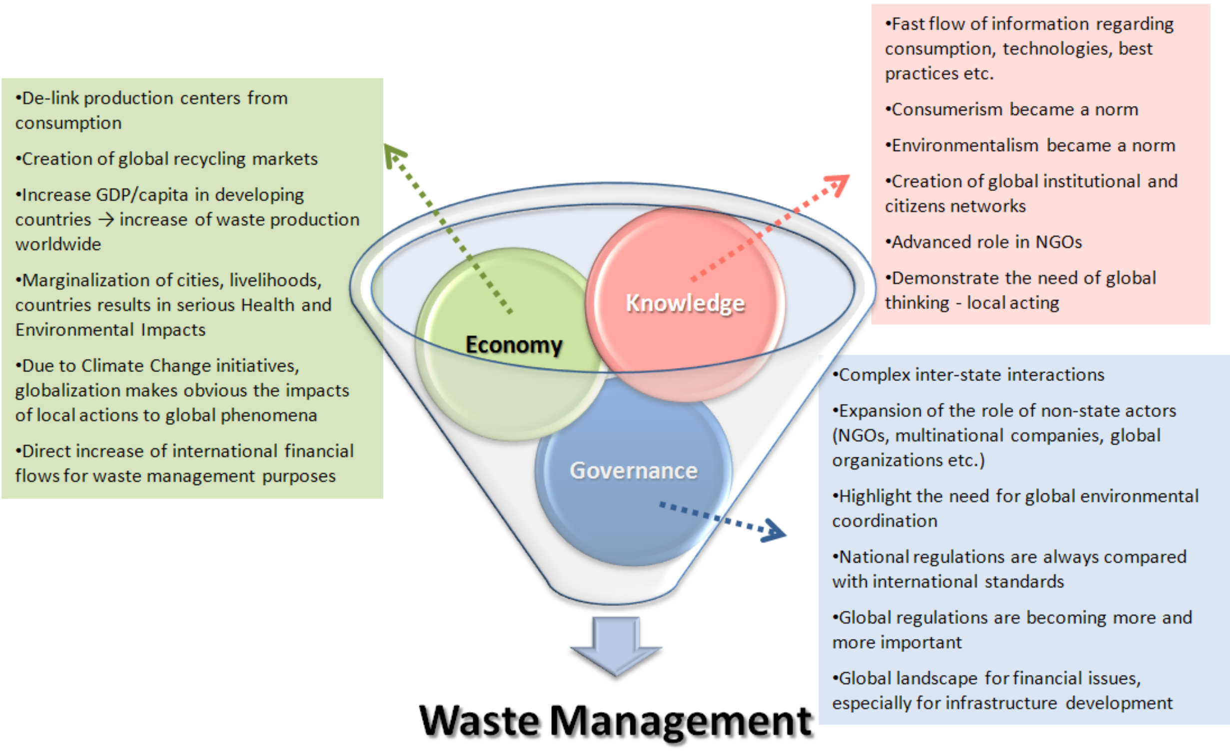

Fig. 2: Globalisation and waste management linkages

The diagram in Fig. 2 presents the conceptual linkages between globalization and waste management activities. The diagram is based on an ISWA's internal document, prepared by the Task Force on Globalisation and Waste Management (2011) with the title "Globalisation and Waste Management-A conceptual approach".

It is clear that waste management in megacities is affected at the highest level from all those linkages. In all the elements of the table 1 there are two questions to be answered. First how those elements affect waste management and second how waste management affects those elements. Those issues will be addressed in more details during the implementation of the project "Globalization and Waste Management" by ISWA.

MEGACITIES AND WASTE MANAGEMENT

Regardless of the context, managing solid waste is one of biggest challenges of the urban areas of all sizes, from mega-cities to the small towns and large villages, which are home to the majority of humankind. It is almost always in the top five of the most challenging problems for city managers. It is somewhat strange that it receives so little attention compared to other urban management issues. The quality of waste management services is a good indicator of a city's governance. The way in which waste is produced and discarded gives us a key insight into how people live.

There is a lot of literature about waste management in megacities (Lundqvist, 2006, Medina, 2000, Fahmi 2010, Mavropoulos 2010). A milestone of the recent literature is the UN HABITAT book "Solid Waste Management in the World's Cities" which has been awarded with ISWA's publication award 2010 (UN HABITAT, 2010). The analysis of 20 reference cities which are presented in more details resulted in three major conclusions.

First, there is no "one size fits all" solution. Second, any successful solution must address both the physical elements (Hardware) and the governance issues (Software) of the Integrated Sustainable Waste management approach (see Introduction). Third, a reliable approach, has to start from existing strengths of the city and built upon them; to involve all the stakeholders to design their own models; and to "pick and mix" adopting and adapting the solutions that will work in any particular situation.

A very frequent problem is the collection of information regarding the actors involved in the waste management system and how the material and resource flow in a megacity is a great challenge in any large urban centre in developing countries, because of the complexity of the system (Escalante, 2009). Furthermore, the difficulty of the task is compounded by the fact that a large part of the waste and resources are managed and recovered informally or at the interface between the informal and formal sectors.

Another useful view is the view of urban metabolism (Brunner, 2007, 2010). As it has been mentioned "…with megacities having a population exceeding 10 million inhabitants, and a material turnover of more than 200 tons per capita and year, the question arises if such intense metabolic systems are limited by the availability of sinks in water, air and soil. The focus lies not on the traditional issues of waste and wastewater treatment or air and soil pollution control. The centre of attention is an integral assessment of entire substance flows form a city over time…" (Brunner, 2010). According this, the need for final sinks has been demonstrated as a key-concept for waste management in megacities.

The different challenges for waste management in emerging- transition megacities and the mature ones have been presented (Mavropoulos, 2010) as in Table 1.

Table 1: Differences between Mature and Emerging-Transition Megacities Regarding Waste Management

Characteristics	Emerging – Transitional Megacities	Mature Megacities
Growth	Faster economic and population growth Younger populations Spatial growth cannot be predicted Waste quantities will increase for many years More organic fraction is expected Land is almost not available	Stabilized economic and limited population growth Aged populations Decline of traditional city centres Suburban spatial growth Waste quantities might be reduced Land has been occupied by current infrastructure
Poverty	Extended slams Restricted access to big areas Collection coverage between 10-70% Informal sector involved in waste management Health risks are still serious	Slams are more controlled and limited Waste management is organized and delivered in certain patterns Collection coverage goes up to 100% Environmental protection and aesthetics are important
Governance	Lack of information for planning – almost impossible to get it Multiple authorities with similar responsibilities Infrastructure delivery and increasing capacity is a key-issue Financial cost will be substantially increased as waste management services will be better	There are plans in place Waste management authorities with more clear responsibilities and limited overlaps Infrastructure maintenance and upgrade is a key-issue Financial cost is already relatively high and efforts are made to reduce it
Globalization	Global nodes Global Risk areas Waste trafficking problems	Global nodes Recyclables exported to emerging – transitional megacities

Other major differences between industrialized and developing countries and cities have been mentioned (Medina, 2000) including availability of capital and labour, physical characteristics of cities, waste composition and informal sector participation to waste management activities. The last one has special importance for any effort to resolve the waste management problem in emerging and transitional megacities.

Special importance has been given at the role of informal sector in megacities. It has been noted (Medina, 2000) that in Latin America and Asia up to 2% of the population of megacities are involved to waste management activities.

The main field of activity of the solid waste informal sector is recycling and recovery of materials. This activity diverts a lot of materials from disposal, and supports livelihoods for millions of poor people. There are cases (OECD, 2006) informal recyclers divert 15-20% of the city recyclables.

A major challenge is to change the political attitudes and the public policies to informal sector. The same is also true for the waste management industry (Wilson, 2006). It is becoming increasingly evident that incorporating informal recycling and collection systems into formal waste management operations and procedures can bring substantial economic, social and environmental benefits. Strategic Planning needs to document, understand and build on existing informal systems (Wilson, 2006 and 2009, Scheinberg, 2007) because all the experiences demonstrate that it will be more expensive and less effective to build a new formal recycling system ignoring the already established one. Of course this is neither an easy nor a simple task. But it seems that there is no alternative.

It has been mentioned (Medina, 2000) that conventional technological approaches to waste management are not working in emerging and transitional megacities because they involve imported solutions that are centralized, bureaucratic and suitable for different socio-economic conditions and so the possibility of decentralized models must be examined.

In most of the cases those conventional solutions are promoted (UN Habitat, 2010) by international donors and aid programs in an effort to export “Western type” technologies. A usual way of such a promotion is the adaptation of certain environmental and technical standards as a condition for funding.

Another approach (Mavropoulos, 2008) explains the technological evolution of waste management systems with the Change Ring model. According the Change Ring model, GDP/ capita is the dominant driver for SWM changes and historically at each GDP level several different SWM systems may correspond. In other words technologies applied are clearly driven by GDP growth but framed by the ring of History, Policy and Know How.

Although it is very difficult to find out conclusions of general importance from the different technological systems applied in different megacities, it is substantially easier to outline conclusions from the negative experiences (UN Habitat, 2010, Mayor, 2002, Medina, 2000, Wilson, 2006, Iskandar, 2009, Mavropoulos, 1999 and 2008) that exist and provide a “Failure Receipt” that has to be avoided (Mavropoulos, 2010).

Table 2 summarizes major suggestions about waste management in megacities.

Table 2: Suggestions for waste management in megacities.

PROBLEM	SUGGESTION
Huge waste quantities	Put emphasis to waste prevention and recycling programs with infrastructure delivery. Develop decentralized recycling initiatives, including the organic fraction of waste that will provide a medium to long term relief of the waste management systems.
Megacities are a patchwork	The overall solution for waste management will be a

of cities within the megacity and livelihoods within the cities	patchwork too, but with minimum standards that will protect health and environment
Infrastructure comes always late	Develop a variety of solutions that fit different city parts – do not wait for central infrastructure delivery without developing low-cost decentralized solutions
Lack of data to plan and implement	Implement Strategic Waste Management Plans instead of detailed master-plans. Create a core of responsible officers and entities that will have the capacity to understand and propose suitable solutions neighbourhood by neighbourhood
Informal sector activities	Integrate informal sector to waste management plans , analyzing local market dynamics and creating appropriate initiatives
Plethora of institutions involved	Create metropolitan authorities to coordinate activities and try to keep legal responsibilities as clear as possible, without overlaps. Create representative waste management platforms to share the responsibilities with all the stakeholders involved.
Lack of space for infrastructure	Define land uses and occupy spaces for waste management activities as soon as possible – examine possibilities for underground development
Health risks from slams	Prioritize areas of the city that are most vulnerable and require on-going monitoring and proactive intervention. Emergency response planning is required in relation with waste management activities

COMPLEXITY AND WASTE MANAGEMENT IN MEGACITIES

Figure 3 presents the overall conceptual relations and linkages that characterize the triangle globalisation, megacities and waste management.

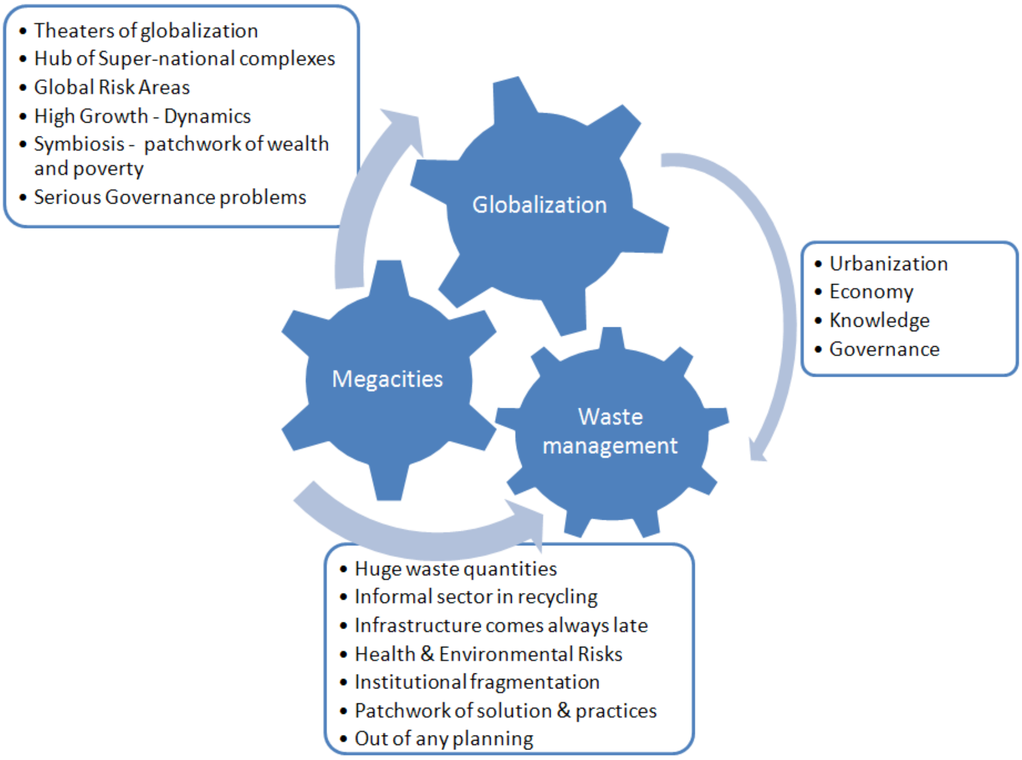

Fig. 3: The linkages of the triangle globalisation, megacities & waste management

It is obvious that a waste management system in a megacity is much more than a local system because a. It is part of the global network of material flows b. It is highly affected by global consumerism trends and c. it is directly influenced by global regulations and initiatives related to waste management

On the other hand it has been mentioned (Brunner, 2010) that "While the supply of goods to cities is mostly controlled by market systems, the disposal depends more on regulation and technical and natural attenuation processes." For a megacity this means that global and local markets determine the input materials and local waste management practices determine the transformation of used materials to waste, including recycling programs that will deliver secondary materials to global and local markets.

That complex dynamics between global and local markets, global and local governance, global and local stakeholders is a key issue for understanding waste management in megacities.

During last years waste management is linked more and more to resource management and so it has evolved in a global complicated network of material and recyclable flows, affecting in various aspects the environment and the life of the citizens, raising questions on practices that need to be deeply explored, and managed in a sustainable way. Megacities, as it is well established, represent the key-nodes of this global network. Part of the sustainability agenda seems to be en effort for more self-reliance of cities, trying to contain waste flows, reduce energy and resource consumption and increase local and global recycling and reuse of materials. Consequently, waste prevention is becoming also an increasing importance trend worldwide.

As a result of those trends, it is obvious that in megacities the Software elements of the ISWM (institutional development, social support and participation and financial sustainability) are becoming more and more important especially for the success of recycling, reuse and waste prevention initiatives. They are highly sensitive to the continuous change of the neighbourhoods and cities within the megacity, especially to the poorest ones where inadequate waste management practices create serious health and environmental risks. Clearly, the Software elements control the social behaviour of citizens and thus they are the most important for the success of recycling, reuse and waste prevention programs.

It seems that a major barrier comes from the complex interactions between the hundreds stakeholders involved in a megacity waste management. Another serious barrier comes from the lack of initiatives to integrate informal sector to waste management activities.

From those remarks, it is obvious that the overall performance of a megacity waste management system results from continuous interactions between global and local markets, emerging social behaviour, city governance, global and local stakeholders, city growth etc. And those interactions are hardly described by the traditional waste management approaches which are based on engineering and logistics.

The problem might be more general. As long as we face SWM as a matter of appropriate storage, collection, transfer, treatment and disposal and the main effort was to minimise environmental and health impacts, engineering and logistic tools were sufficient to plan and implement waste management systems. But today, resource management and social behaviour are becoming an organic part of any waste management system and they are essential to address increasing recycling rates and better quality of recyclables, participation of industrial stakeholders, eco-design initiatives and closed loops of products and materials.

Consequently, engineering and logistic tools are not enough to plan and deliver waste management systems. Especially in a megacity, the overall waste management system should be considered as “complex system”, which means a system composed of interconnected parts that as a whole exhibit one or more properties (behaviour among the possible properties) not obvious from the properties of the individual parts (Joslyn, 2000).

Complexity theory and Complex Systems Science (CSS) is a relatively new field of research focused on systemic understanding, self-organization, irreducibility, emerging patterns and properties and non-linear behaviour. Complexity science has been rapidly evolved during the last 20 years for the study of complex physical, biological and social systems. Cities as a whole may be considered as emerging entities existing near a critical point of self organization, far from equilibrium and qualitatively different from their constituent residents and subsystems (Baynes, 2009).

Waste management systems in megacities should be studied using complexity theory and complex systems science tools because:

- The overall performance of a megacity waste management system is the result of complex interactions between global and local stakeholders, global and local material flows, global and local recycling markets, global and local governance etc.
- As it has been already mentioned effective recycling, waste prevention and reuse programs are of high importance for a megacity since they improve self-resilience and relief waste management systems. However, those programs are directly linked with social behaviour and the emerging system performance is a result of thousands or millions daily interactions.
- In megacities, local patterns and heterogeneity are the rule in waste management and micro-local dynamics have an impact at the system performance through their aggregate effects but also because they influence urban change iteratively through local connections and impacts.
- In metropolitan areas there are a number of councils, utilities, regional and governmental authorities, NGOs, private sector companies, informal sector unions, municipal utilities etc. Each of these entities is operating according the rules of limited awareness and jurisdiction, and self-interest and with selected connections to other entities. The dynamics of stakeholders’ interaction in megacities cannot be predicted or modelled with the usual information tools

<u>CONCLUSIONS</u>

Waste management systems in megacities are the result of the dynamics and the interactions that characterize the triangle globalization, megacities and waste management. For that reason, waste management systems in megacities should be considered as a complex system. Such an approach becomes more necessary as long as waste management is linked directly with resource management and the importance of social behaviour and governance issues becomes crucial for the system's performance. Such an approach might open new ways of thinking waste management systems in megacities, using the tools of the complexity theory and science.

Last 20 years, there is a remarkable progress in different modelling approaches of cities' organized complexity using Cellular Automata (Gardner, 1970, Engelen, 2008), Agent Based Models (Portugali 1999, Batten, 2006) and Network models (Ashton, 2008, Hardy, 2002). A lot of those efforts are focused in urban metabolism and industrial ecology, according the priorities of the sustainability agenda.

Complexity theory and Complex System Science do not represent a complete approach to measuring and modelling sustainability but they provide useful tools to find positive intervention in urban management (Baynes, 2009). One of their key-advantages is that they can also take into account learning and behavioural responses that may be diverse, heterogeneous or even irrational and thus they have the capacity to involve stakeholders' response to policy issues and planning (Baynes, 2009).

For that reason, complexity theory and science is very helpful to improve understanding of systems' function and to map interactions between different parts and emerging behaviours, especially in the cases where social and political uncertainties are important. Thus, complexity theory may open new opportunities for policy makers to adopt more holistic and organic policies that previously were not considered (Batty, 2007, Baynes, 2009).

A good starting point towards the use of complexity tools for a better understanding of waste management would be to substitute the idea of planning a waste management system with the idea of a bottom – up evolution of such a system, which in fact is true in most of emerging and transition megacities. Such approaches have been already tested with success for different city characteristics like the expansion of residential areas and the traffic problems.

A milestone will definitely be an effort to include social and behavioural issues in waste management modelling approaches. Such a modelling approach can be implemented by Cellular Automata or Agent Based Models. The same is true for modelling the complex interactions between the hundreds of stakeholders involved.

Another useful idea would be to analyze the many feedbacks that exist in a waste management system that determine what is called "sustained disequilibrium of the system".

In any case, the application of complexity tools will help us to understand better and in more depth the overall performance and the interactions that finally determine the waste management system in a megacity.

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