AN INTERDISCIPLINARY APPROACH FOR INTRODUCING SUSTAINABLE INTEGRATED SOLID WASTE MANAGEMENT SYSTEM IN DEVELOPING COUNTRIES: THE CASE OF LA PAZ (BOLIVIA)*

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Abstract

Solid waste management (SWM) has become one of the most difficult environmental and political issue in developing countries worldwide. The increase of diseases from uncollected waste, inadequate informal collection and/or waste open dumps are only few unsustainable practices that affect low income countries population health. The international cooperation between developing and developed countries can be an affordable solution in order to implement new recycling policies and environmental sustainability. In fact, the lack of management instruments and insufficient monitoring and accounting can be solved by introducing long term processes and by involving all local institutions. However, this challenge includes several social, economic, environmental aspects, and implies the development of technical abilities in many disciplines. This article moves from a field research work aimed to develop sustainable integrated waste management policies. That has been made possible by applying university international agreements and public-private partnerships. The work took place in the Bolivian capital city (La Paz), with the direct collaboration of three Universities (University of Trento – DICAM, Major University of S.Andrés – IDEPROQ, Salesian University of La Paz). During the field study the NGO Swisscontact and the La Paz Municipal Government were involved. They helped to investigate directly

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city waste management daily difficulties. Furthermore, an Italian waste recycling company (EliteAmbiente) has been involved in the project, in order to estimate the process cost and the management needs for introduce a recycling industry. The process is going to continue with an enlargement of the working group and with other agreements that will involve other institutions. The main issues are widely discussed in order to explain the advantages and the difficulties that have been found while implementing this integrated process. Moreover, the methods to implement the study are focused and some future objectives are presented.

Keywords: Developing countries, International Cooperation, Integrated approach, Waste management

1. Introduction

SWM emerged as an essential specialized sector for keeping cities healthy and livable. Rapid population growth, urban spread and change in consumption styles are just three examples of primary factors causing increase in waste generation (Ragazzi et al., 2014; Saeed et al., 2009; Sukholtthaman and Sharp, 2016). Due to economic crisis that is troubling emerging cities (Kinobe et al., 2015) and due to high recyclable waste fractions (Mohee et al., 2015), recycling is now seen as a sustainable approach to SWM. Additionally, recycling has become a successful waste management method to solve environmental pollution and increase in human disease, which leads to increase collected recyclable waste and to decrease waste inflow to landfills. However, lack of recyclable materials markets, inconsistent waste separation campaigns and lack of public participation do not allow recycling activities improvement (Potdar et al., 2016). Municipal authorities in emerging countries are starting to promote recycling as an industry (Batool et al., 2008; Ghinea et al., 2014) although it is necessary to considerate that economic, environmental and social factors should be studied and improved simultaneously in order to achieve visible results in long time prospective.

Bolivia SWM organization lacks in technological facilities, public financing and national clear regulation systems that aim to reduce solid waste in order to decrease environmental pollution and increase human life quality. Like it happens in other developing countries, most of landfill sites are open dumping areas, which pose serious environmental and social threats (Manaf et al., 2009). Effective solutions need to be urgently developed and specifically to local needs and conditions. Users and potential users must need to be involved and services must be provided at a cost that is locally affordable (Wilson et al., 2013). Furthermore, measures to avoid the negative impacts from irregular solid waste flows and to introduce recycling policies must go beyond public regulations, education and legal framework (Gutberlet, 2015). In order to achieve new management systems and integrated approaches stakeholders involvement is required.

This study introduces and applies the concept of sustainable, affordable and integrated approach as regard improvement of SWM for emerging big cities, in particular for La Paz case. It has been possible due to the cooperation process involved between Bolivian and Italian Universities, private Italian companies, local authorities, NGOs and local users. The objective of our paper is to explain the feasibility in introducing, within developing countries municipalities, integrated SWM and recycling policies by a cooperation process that involve all local and international stakeholders. Steps and issues are fully explained in order to suggest this method for other new cooperation processes, between Europe and worldwide emerging countries, useful to overcome financial, technological and human barriers.

The present work is divided in four main parts:

- description of La Paz current waste management difficulties;
- analysis of the La Paz stakeholders and the actors involved within the integrated process;
• description of the studies made for the introduction of waste recycling companies. The example and the flow chart that we are going to propose are useful both for developing and developed countries;
• final discussion on the integrated approach used and proposed to the local Government. Conclusions and remarks are described to suggest an integrated approach in recycling processes introduction, highlighting the involvement of multiple stakeholders and specialized experts. After this research, new agreements will be signed and new initiatives will be proposed.

2. Case study, materials and methods

2.1. Working team

The work started with an international agreement, between two Bolivian Universities (Major Universities of S. Andrés – Department of chemical Engineering and Salesian University of La Paz) and University of Trento – Department of Civil, Environmental and Mechanical Engineering, inserted in a Thesis work for a graduation in Environmental Engineering with specialization in emerging countries and international cooperation. In the frame of this agreement a three month field work has been carried out in La Paz, where current municipal solid waste collection and treatment were studied and local stakeholders were involved. Before the field research, an Italian special waste recycling company (EliteAmbiente), expert in plastic and metal materials treatment, has been involved in the work giving industrial knowledge in recycling process and accounting. Needs for industrialize recycling processes were highlighted and analyzed for the specific La Paz study area.

Preliminary knowledge and agreements allowed working with the La Paz local Government that, after the useful results obtained from this research, would be interested in implementing the project and continue the cooperation process through future programs. An NGO (Swisscontact) has been involved during all the field work, for its specific knowledge in La Paz SWM and for the interest in introducing new recycling policies. The stakeholder involvement, with a preliminary study of documents and past studies, allowed understanding difficulties, threats and opportunities in La Paz SWM system. Preliminary knowledge about solid waste collection and treatment are necessary in order to understand difficulties and opportunities in La Paz case study: so, the current situation within La Paz SWM is now shortly presented.

2.2. La Paz current municipal solid waste management and treatment

La Paz, Bolivian capital city located between the Andean plateau and the Bolivian Royal mountain chain at an altitude of 3,600 m, is facing with the typical SWM problems of developing countries even though is one of the most developed cities in Bolivia. Lack of efficient environmental monitoring, poor education and public awareness, unsuitable waste collection for low income areas, not well-structured and executed recycling programs, low recycling rate (about 8%) and low financing sustainability are only few of the current issues that La Paz Government must solve. The first Law in solid waste organization was established in October 2015. Because of its recent introduction in public management system, that Law is not yet enforce and regulations are still lacking. However, that Law is the first step in introducing sustainable aspects in SWM like the “polluter pays” principle or pollution monitoring.
The total waste generated in La Paz achieves 600 tons/day, about 0.63 kg per person. The 92% is disposed at the *Alpacoma* landfill, disposal site 15 km far from the city center, where all kind of waste fractions are discharged. The *Alpacoma* area is bounded and constantly controlled; waste discharged is daily covered. Environmental monitoring is present although not perfectly and continuously in coherence with European standards. Local Government introduced a vermicomposting facility for the organic matter that comes from markets and the zoological park and a manual selection plant, where plastic, cellulosic, glass and metal fractions are divided though in low rate. Despite that, sustainable plans for future waste material exploitation were not introduced and new recycling policies were not proposed by the local authorities. In the city the distribution of the collection containers is often counterproductive and the number of collection vehicles is inadequate, similarly in other developing cities (El-Hamouz, 2008). In addition, the landfill can be used just three years more: after this period, new projects for the enlargement of the area will be introduced. Nevertheless, near the city are not available new free areas where a new landfill could be built. So, after 15 years, where will be disposed the municipal solid waste?

Like typically happen in developing countries, the recycling rate is improved by the informal sector and from scavengers who separate exploitable materials from street containers and informal dump sites along the city, building a little informal recycling chain (Batool et al., 2008). This activity avoid waste inflow to the landfill, helping municipal economic save, however these people, that mostly are poor, woman and children, are in low working condition hence affected of disease and low public recognition. Organized recyclers are an important link in the resource recovery chain but in Bolivia are not recognized by the public institutions.

The local Government, in particular the Environmental Services Secretary, pays three private companies for collection, treatment and final disposal of solid waste. Moreover, local Government has the power to change the current service provision, introducing new developing plans and sensitivity campaigns for the population. Nevertheless, financing is not sufficient to improve new program because 60% of the total costs are covered by the national Government. The agreements between private and public sector are going to be renewed in November 2016: this represents a good opportunity to implement new sustainable practices: reverse logistic could be introduced within SWM service. This context is perfectly useful to change current collection and treatment systems and the lack of financial resource and know how could be overcome by international cooperation and new alliances with recycling companies and foreign institutions.

3. Results and discussion

The results of this paper present the international cooperation and the introduction of sustainable aspects that aim to involve all the stakeholders into developing recycling polices in La Paz case study. The sustainable aspects of international cooperation are introduced.

3.1. Stakeholders analysis and actors involved within the process

Stakeholders’ analysis, appropriately adjusted for a certain system, can provide an useful integration to traditional methods by assessing additional aspects to ensure a comprehensive picture of the situation in SWM and other public services (Caniato et al., 2014). Stakeholder involvement is the primary tool to implement new integrated systems in order to achieve sustainable policies in all environmental aspects (Zortea and Lucatello, 2016). Like suggested in other studies, problems tackled by multiple stakeholders are likely to acquire more attention in near future, while more opportunities will rise thanks to the
provision of newer waste treatment techniques (Soltani et al., 2015). Hence, this study introduces a method to realize a multi-stakeholder approach with multi-disciplinary studies in the frame of an international cooperation. Actors involved in this survey are:

- Universities (Salesian University of La Paz, Major University of S. Andrés-IIDEPROQ, University of Trento-DICAM);
- Governmental authorities (Environmental Services Secretary);
- Private sector (Bolivian engineers and services providers and an Italian company);
- Non-Governmental organizations (NGOs) and local media (Swisscontact and the Major University of S. Andrés television).

Salesian University had an important role in users survey implementation. Indeed, the field survey started into the University, interviewing students and professors about environmental issues and waste management problems within the city. This approach allowed entering rapidly into local citizens thought, understanding which issues are most dangerous for the local population. The field study has been completed in collaboration with the department of chemical engineering of the Major University of S. Andrés since it is the University where all engineers expert in waste management work. Moreover, links with the local Government and local NGOs had been made thanks to this collaboration. The NGO Swisscontact works from 2008 in La Paz SWM and has many knowledge in the field, whereas local Government is the direct actor of SWM in the city and is the main subject of the work. All field work has been made in order to introduce new sustainable systems in La Paz SWM in collaboration with the local Government that has a direct contact with collection and treatment providers. In addition, our work had been exposed to the local University television in order to explain to the region population the project involving Bolivian and Italian Universities.

The aim of the work is to introduce the reverse logistic system in the city, suggesting methods and collaborations useful to implement this approach. Italian private sector involvement is considered an effective solution to implement a circular economy model within the city, because an industrialized recycling system is still lacking. According to Ahmed and Ali (2004) some conditions are required to establish successful public-private partnerships: a positive culture that encourage leaderships and public participation, a realistic commonly accepted vision among all the stakeholders involved, participatory methods within local policies and long term policy with ability to change circumstances and to reduce uncertainty for business and individuals who want to take economic risks. Private sector involvement, for instance, has been revealed as an effective solution whether introduced in the collection system (El-Hamouz, 2008). In La Paz case study this involvement results in a good option also for the recycling process, since lack of public financing do not allow implementing big recycling chains. The example suggested in this work is the introduction of the private company EliteAmbiente, specialized in plastic and metal recycling processes. The collaboration with an industrialized company, capable to well exploit recyclable waste materials, can provide a new way to local authorities and improve public awareness in environmental subjects.

Within the process suggested in this study, universities had the most important role in introducing new agreements between private companies and public institutions. Moreover, students and professors helped us to study preliminarily SWM current situation, saving costs and time to local authorities and international companies. A scheme explaining strengths of these collaborations is suggested in Fig. 1. The scheme sums up the project influencing, capabilities of each actor useful to achieve sustainable objectives in SWM, and, finally, opportunities for all. Within a public-private partnership, Universities are an important actor in the effort of providing integrated approaches into public services.
Fig. 1. Actors involved in La Paz case study and related functions.

Collaboration among all actors above described allows even to save monetary resources, to promote international partnerships and to introduce new technological approaches taking into account local needs. In a theoretical approach, partnerships between such actors must start along with a global vision of integrated attitudes where environmental protection, financial sustainability, human healthy, international collaboration and multi-disciplinary studies are introduced like a common objective. Every actor can provide specific knowledge and capabilities, helping the implementation of new programs. As in La Paz case study, Universities agreements provide new integrated management tools to the Governments, preliminary studies for Italian companies and new collaborations useful to introduce a reverse logistic system within La Paz SWM. Indeed, a multi-disciplinary international benchmark indicator had been provided to the local Environmental Services Secretary to compare SWM of other cities worldwide and to understand current waste collection and treatment services quality within the city. So, the collaborations born within this research are going to move in agreement with the theoretical approach principles above listed.

University agreements are the backbone allowing the current project to be developed with a recyclable materials market survey and with a pollutant effects and technological solutions study and it will guarantee also the financial sustainability: low additional will be required. The collaborations with all stakeholders described in this paper are still in action. Another agreement, between Insubria University (Italy) and Bolivian Universities, is about to be signed, in order to enlarge the collaboration activity and the experts involved in the process. Additionally, an agreement between local Government and Italian Universities is in
progress. The study proposed to recycling companies and the field work applied in La Paz are schemed in the following section.

3.2. Sustainable studies and recycling company introduction

In La Paz case study, like it happens in other developing cities, circular economy is not yet developed; hence no specific regulations regarding quality of the recycling products have been introduced by local institutions (Kinobe et al., 2015). However, participation by local private factories is increasing, even though they are not so developed due to the lack of knowledge and market surveys. Like suggested in other studies, setting up recycling industries generate revenues, new jobs and city wellness at the same time (Batool et al., 2008). Moreover, high waste separation rates mean less amount of waste brought to landfills, less total management costs and higher public collection service efficiency (Sukholthaman and Sharp, 2016). Therefore reverse logistic approach has been introduced in this project and its implementation has been recommended to La Paz local Government. However, with respect to private investors considering risks and returns, waste management projects are quite unattractive in developing countries due to insufficient stakeholder awareness and public perception (Bufoni et al., 2016). Despite that, private company involvement in environmental initiatives always leads to service costs saving and waste quality processes improvement albeit the ‘environmental respect’ principle required high managements costs in the short term (Flores, 2009).

In this article recycling companies introduction is suggested. However, waste flow analysis, economic survey and local area current SWM situation assessment are required in order to estimate intervention feasibility (in all typology of study areas). Collaborations with Universities and EliteAmbiente private company allow studying recycling process general needs for the recovery procedure. Fig. 2 illustrates the steps useful to understand the feasibility for recycling company introduction in a specific area.

**Fig. 2.** Flow chart of the four steps useful to introduce recycling companies in new areas
Available resources, local energy costs, life cost, local charging, money value, local know how, waste water treatment plants, available markets for recycling materials and appropriate sanitary landfills have to be accurately assessed through further field study, where stakeholders’ collaboration will provide useful information. These preliminary surveys are necessary to better understand the feasibility of recycling company intervention: for instance, this methodology has been used for La Paz case study where all main data have been carried out.

As suggested in other papers, in order to develop a new waste management system it is necessary, first of all, to assure good data collection and available waste fractions amounts (Ghinea et al., 2014; Murariu et al., 2015; Wilson et al., 2012). The field work will allow gathering these information and summing up the current La Paz SWM situation. The chart, presenting schematically all steps needed to achieve such objectives is depicted in Fig. 3. The first part of the survey regards the study of local laws and regulations: without solid legal framework, international investments to introduce technological facilities are considered a high economic risk by private sector. The second step is setting up the waste material fraction and amounts analysis. As common in developing countries, waste fraction and quantities information are not available.

Nevertheless, some useful indication can be obtained by analyzing past local studies. More difficult is the assessment of recycling process costs because local institutions and past studies did not focused on this aspect. However, thanks to the collaboration with EliteAmbiente, the university and the experts in the economic sector involvement, it has
been, as usual in developing countries, it cannot be implemented in the future due to the economic autonomy weakness of local institutions. Then, ample recycling markets surveys are required to complete the reports in order to assess material prices fluctuations and most advantageous markets. However, in La Paz case study, recycling company introduction is feasible and potentially affordable for what concern the process costs and exploitable materials quantities (about 30,000 tons of plastic waste per year).

Municipal solid waste is a valuable resource offering several social, economic, environmental and technological benefits if introduced in a “clean developing mechanism”, as exposed in other studies in developing countries (Potdar et al., 2016). The exploitation requires public-private partnerships, municipal awareness, financing sustainability and current SWM updated surveys. International cooperation and collaborations between stakeholders can help to achieve these objectives in order to reach Social, Economic and Environmental Sustainability.

Moreover, social inclusion programs might be developed in order to include population involved in the recycling process and increase public awareness, like suggested in other studies in developing countries (Vaccari et al., 2012). Sustainability of the solutions should be evaluated considering both the results of Life Cycle Assessment (LCA), the costs of the different operating scenario and the stakeholders involvement, that should take part in selecting the most appropriate solution (Bamonti and bonoli, 2014; Ghinea et al., 2014; Torretta et al., 2015).

So, future researches will be focused on: LCA of SWM processes; surveys about recyclable materials markets; impact assessment of pollutant in water bodies; air and soil degradation assessment from illegal waste dumping and burning and, finally, monitoring the introduction of private recycling facilities in La Paz solid waste treatment systems as suggested by other studies (Guerini et al., 2015; Vaccari et al., 2012). All activities will be carried out, in collaboration with local stakeholders and users.

6. Concluding remarks

La Paz is facing the typical emerging countries SWM issues due to poor financing sustainability, low public awareness and lack of recycling programs. Public private partnership can improve efficiency in SWM and create new opportunities for employment, environmental protection and city cleaning by the introduction of new industrialize recycling facilities. In order to develop a reverse logistic chain and recycling policies in La Paz, an integrated approach and coherent management programs are required. To that purpose, stakeholders cooperation, Universities inclusion and international agreements among all partners, can allow improving current SWM rapidly and in a sustainable manner, avoiding typical mistake made in the past by developed countries, resulting in environmental pollution and human healthy. An important aspect that cannot be underestimated is time necessary to draw up the agreements between stakeholders.

The incorporation of circular economy into SWM systems is also effective in increasing landfill useful life, reducing collection costs, and also in providing economics improvements. Moreover, it sends in environmental benefits that can be also translated into greenhouse gases reduction and climate change mitigation.

Such multi-stakeholder and interdisciplinary cooperation approach represent a sustainable way to ensure a long term process aimed to improve human health and environmental protection, capable to involve all local institutions.

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