AES BIOFLUX
Advances in Environmental Sciences - International Journal of the Bioflux Society

Developing a municipal urban waste management integrated system in Cluj County

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Abstract. The need to develop and modeling an integrated waste management system from the urban population in Cluj County is founded in evaluating the current waste management system. This system does not pursue the objectives of the national and European strategy for waste and does not link with the environmental existing problems in the county. The integrated management proposed system includes all stages passing through the population beginning the selective collection and to disposal.
Key words: selective waste collection, packaging waste, biodegradable waste.

Rezumat. Necesitatea modelării şi elaborării unui sistem de gestionare integrată a deşeurilor provenite de la populaţia din zona urbană în judeţul Cluj se regăseşte în evaluarea sistemului actual de gestionare a deşeurilor. Acest sistem nu urmăreşte obiectivele strategiei naţionale şi europene de gestionare a deşeurilor şi nu se corelează cu problemele de mediu existente în judeţ. Sistemul de gestionare integrată propus include toate etapele prin care trec deşeurile provenite de la populaţie, începând cu colectarea selectivă şi până la eliminarea lor.
Cuvinte cheie: colectare selectivă, ambalaje, deşeuri biodegradabile.

Introduction. The current management of waste in urban areas in Cluj County fails to comply with the existing national and European legislation. A viable system of selective collection of waste at source was not yet implemented. Additionally, an ecological county landfill does not exist for the moment, or waste incineration as an alternative intermediate step. Beyond the current efforts to resolve some of the raised issues, a project of integrated waste management system was initiated.

Responsibility for the municipal waste management belongs to the local authorities, which have to find ways to efficiently collect, transport, and eliminate the municipal waste. Data collection on municipal waste management is performed by the county environmental protection agency, based on statistical questionnaires from the sanitation operators. The collected data rely on estimates obtained by weighing and not on accurate data. These data refers to the municipal waste and to the commercial and public institutions waste (REPA, Data base, 2009).

The amount of municipal waste generated in Cluj County is significantly higher in urban areas, with a generation index higher than 0.9 kg/capita/day, compared to 0.4 kg/capita/day in rural areas. The income level is the determining factor which influence the quantity and composition of household waste, but there are significant variations depending on season or even from week to week (REPA, RWMP 2007).

The targets and the objectives are well defined in the specific waste legislation. They are included in the Waste Management Plan of Cluj County and express each objective established in a quantifiable form (quantity and time). They are at least equal to the targets set at regional and national level, but at county level intermediate targets can be set (Cluj County Council, Waste Management Plan).

The goals and the objectives are structured as follows: waste prevention, recovery of useful potential of waste, waste collection and transport, waste treatment, disposal, Electrical and Electronic Equipment Waste (EEEW), packaging and packaging waste,

biodegradable waste and bulky waste. For each target or goal there are deadlines, but in many cases the deadlines are not met.

Materials and Method. The current situation of the management of waste from the urban population of Cluj County is summarized below. The purpose of this description is to identify the waste types and quantities and the weaknesses existing in the organization of the waste management system. Given that for the categories of wastes from the above population, data are not separated, there was a comparative assessment of the amount of municipal waste collected in Cluj County, and existing data was used for 2006, 2007, 2008, and 2009 from the Report on the State of Environmental Factors, Region 6-NW (REPA, Data base, 2009).

The quantities of municipal and similar waste generated in 2006, 2007, 2008, and 2009 can be seen in Figure 1 (REPA, Data base, 2009).

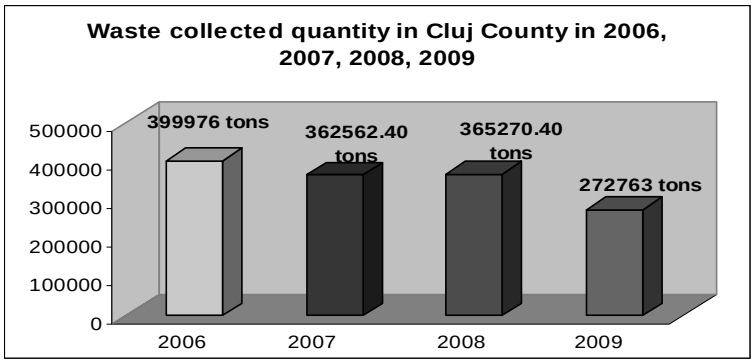

Figure 1. Municipal waste collected quantities in Cluj County in 2006, 2007, 2008, and 2009 (REPA, Data base, 2009)

Figure 1 shows a decrease of the amount of collected waste in 2009 compared to 2006. This decrease can be attributed to the reduction of household income due to the recent period of crisis facing Romania.

Biodegradable waste has the largest share in urban areas (61%), than plastics waste 16%, paper and cardboard 7%, followed by other types of waste (Fig. 2). Table 1 shows the situation of biodegradable waste entering the landfills in 2009, in Cluj County. According to these data, the amount of biodegradable waste ranges between 29 and 80%.

Table 1

Situation of biodegradable waste entering the waste landfills in 2009 (EPA Cluj, database)

Landfill	*Waste in the landfill*		*Biodegradable waste in the landfill*	
	quantity, tons	*%*	*quantity, tons*	*%*
Pata Rât Cluj-Napoca	197623.00	100	96835.27	49
Turda	24739.40	100	7174.40	29
Campia Turzii	20789.30	100	9355.20	45
Gherla	23949.00	100	9100.62	38
Cetatea Veche-Bolie-Huedin	8674.00	100	6939.20	80

In the Figure 2 can see the location of the landfills presented in Table 1.

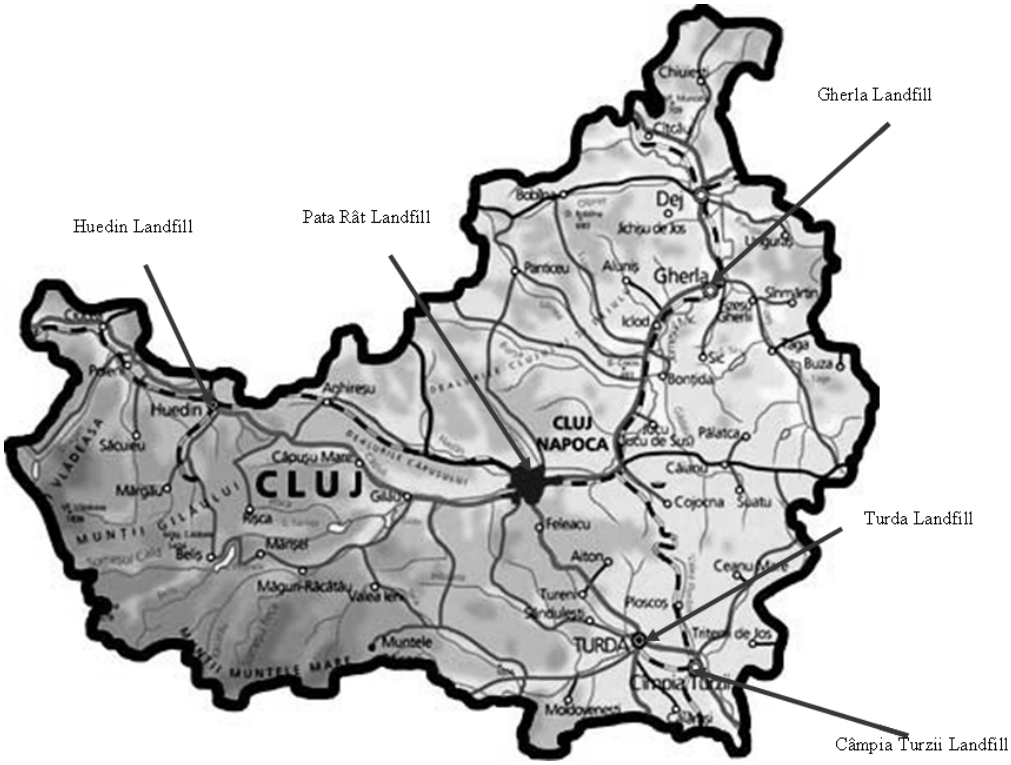

Figure 2. County Cluj map with the locations of the main landfills.

Compared with the targets that are in accordance with the legislative requirements, the quantities of biodegradable waste reaching the waste landfills are very high. In Cluj County there is still no operating facility for recovery through composting the municipal biodegradable waste, so they all get to the landfills (EPA Cluj, database). Biodegradable waste treatment capacity is very low compared to the specific objectives related to the separation of biodegradable waste in storage. There is no market for the resulting compost from biodegradable waste.

The situation of the packaging waste

According to the existing legal provisions, the responsibility for the separate collection and the management of packaging waste from households belongs to the local administration. The collection of the municipal waste is being done by sanitation services, the operating way depending on the size of the locality, the number of inhabitants, and the existing equipment. It may be different from one place to another within the same locality and from one neighborhood to another. The waste is generally taken on a daily basis in crowded areas and more rarely, up to once a week in areas with low population density.

In 2009, in Cluj County increased the population surrounding the selective collection system at source by placing containers for separate collection, mainly of paper/cardboard and plastic (REPA, Data base, 2009).

The quantity of selectively collected waste, especially paper/cardboard and plastic, slightly increased in 2009, as a result of the implementation of some European projects.

Table 2

Situation of volumes of packaging waste collected by collection at source through the European projects, in 2009 in Cluj County (REPA, database, 2009)

Cluj County	*Total quantity (tons)*	*PET (tons)*	*Plastic (tons)*	*Paper/cardboard (tons)*	*Glass (tons)*	*Metal (tons)*	*Wood (tons)*
	125.43	35.10	4.71	79.41	6.21	0	0

The quantity is 0 tons for metal and wood, because these waste streams were not included at the time in the selective collection at source system. The number of inhabitants taking advantage of the selective collection service is presented in Table 3.

Table 3

Population that selectively collected packaging waste and the total collected amount (EPA Cluj, Data base, 2009)

Cluj County	*No. inhabitants in 2009 in Cluj County*	*No. of people benefiting of the selective collection service*	*The total amount of packaging collected (tons)*
	690299	76656	270.10

In 2009, Cluj County had a stable population of 690299 inhabitants. Out of the total county population, 459865 people live in urban areas, the degree of urbanization of the population being 66.62% and 230434 people live in rural areas (EPA Cluj, Data base). It appears that only 11% of the county residents are taking advantage of the selective collection system. The separation of packaging waste takes place in collection points and not at source.

Cluj County has two recyclables processing units: one for paper and cardboard, and one for plastic. Recycling capacity is 1.8 tons/year for paper and 85.2 tons/year for plastic. (EPA Cluj, Data base).

The situation of the non-compliant waste landfills in the county

Currently, the most of the generated municipal waste is stored. In Cluj County there are 4 non-compliant landfills 'B' in urban areas. These landfills will cease to operate, according to the law (Romanian Government 2005, Medana Company, 2010). Besides the four ones, there are two non-compliant landfills which have ceased to operate: Pata Rat, Cluj and Cetan Dej.

Five out of six non-compliant municipal landfills have received the notice of closure compliance program (Pata Rât, Câmpia Turzii, Gherla, Turda and Dej). These landfills will be closed in accordance with the requirements of Directive 1999/31/EC, maximum two years after ceasing the storage (EPA Cluj, database). The closure and cleaning of the municipal non-compliant landfills in Cluj County is expected to be included in the Integrated Waste Management System.

For a better understanding of the proposed model of a municipal urban waste management integrated system in Cluj County, a description of these categories of waste should be useful. Waste streams to be analyzed are:

- Household waste:
  - Packaging waste: glass, cans, PET, ferrous and nonferrous metals, paper (cardboard, magazines, newspapers, catalogs, etc.)
  - Bulky household waste (old furniture, etc.)
  - Household hazardous waste (eg: dye tubes, etc.)
  - Mixed solid waste (cork, plastic bags, cigarette butts, makeup, etc.)
  - Electrical and electronic equipment waste (EEEW), portable batteries
  - Organic waste (food scraps)
  - Green waste
- Street waste (waste dumped in rubbish bins on the street)

It was considered that all the above waste categories are generated directly by the population and therefore it is necessary to analyze how the population may be interested in the selective collection.

In the context of the municipal waste management current situation, the paper proposes a model of an integrated waste management system, based on comparative analysis of different integrated waste management systems in European countries with tradition in waste management, such as the Netherlands, Finland etc, based on existing

legislation requirements, existing opportunities in the county, and the examination of statistical surveys of the proposed model acceptability, performed on a sample of 50 persons in urban areas with different ages and incomes.

The analysis of different integrated waste management systems in European countries with tradition in waste management shows that an organized and selective collection at source, the place where they are produced, is extremely important. In this way it is possible to reuse and recycle large quantities of waste, leading to a decrease in demand for primary raw materials. The use of secondary raw materials is often less expensive. In European countries the recycling average is over 65%, increasing to 90% for some fractions such as glass and metals.

In the Netherlands there is a selective collection of waste from door to door, 5 bins, both for houses and apartments:

- A bin for paper - a collection once a month (tied in bundles and removed at the street), transported to the recycling paper mills
- A bin for mixed solid waste – a collection every 2 weeks, incineration with heat recovery, magnetic metals are recovered from incinerator
- A waste bin for textiles - quarterly or central collection of charitable organizations
- A bin for organic waste-collection once a week or two weeks- are used for composting. (Hermens et al 2010)

In Dutch city centers, because of the low quality of the organic waste it is no longer practical the collection at source and it will be incinerated as a whole fraction (Hermens et al 2010). Paper also is collected in schools or clubs, and an income is obtained from selling to the paper factories. For glass, PET and cans, collection centers are called "collecting bank", located near shopping centers and residential areas. Glass is collected in three categories: white, brown and green. Practice the storage system. EEEW and bulky waste is collected monthly on request or from door to door. There is a municipal unit (mandatory) for collecting waste from households where residents can take this waste. Citizens benefit from awareness and information campaigns and from a calendar of activities of different types of waste collection (Hermens et al 2010).

Recyclable household waste in Denmark (Aarhus) are collected mainly through a well-established recycling system for paper and glass and also for biodegradable waste in some localities, but collection systems for other types of packaging are developing. New initiatives have emerged that may increase the recycling rate and can improve existing schemes, as they proved to be functional. Collection services for single houses or apartment buildings in suburban areas are similar. Source separation of paper and glass is achieved mainly through a centrally placed container system (1 to 600 citizens), and to a lesser extent the recycling centers (1 in 60,000 people). In addition, approximately 40% of waste paper was collected through a collection system on the sidewalk, mainly for apartment blocks in many cases where collection points are established with shared small containers. The collection of residual waste on the sidewalk was compulsory for all households. Implementing this system requires three containers for each house or block of flats: one for residual waste, one for paper and one with two compartments for glass and packaging waste. At the same time, waste incineration with energy recovery and electricity and heat production, is an integral part of the energy system in Denmark (Larsen et al 2010).

Merrild (2009) demonstrated that recycling is a better solution than incinerating in terms of environmental performance, even in cases where competing with high-efficiency energy recovery. A case study has shown that material recycling is beneficial to the environment even when management option is high efficiency incineration with energy recovery (Larsen et al 2010).

In Spain (Castellón de la Plana) the household waste collection is based on a combination of selective collection of glass, paper/cardboard and packaging at the so-called "materials banks" (collection points) and the rest waste collecting on the street. In 2007, with this management system were collected 7.47% from all waste material at banks, the composition is as follows: glass 1.43%, paper/cardboard 5.02%, packaging 1.02%. The remaining 92.53% is owned of the waste collected in containers on the

street. After the compaction at a transfer station, this waste is sent to a materials recovery facility where the following fractions are separated:
- Organic materials used for compost
- Recyclable fractions (paper/cardboard, plastic, ferrous and nonferrous), which is sent to recycling plants. The final residue obtained is compacted into bales and sent to storage without energy recovery (Bovea et al 2010).

In Sweden a waste management system involves at least three stages: collection, transport and treatment. In the Swedish system, producers should consult and cooperate with municipalities concerned about collecting systems. It is also needed to collect data on the outcome of the collection, recycling and energy recovery and to report to the Swedish Environmental Protection Agency (SEPA). Consumers in turn are obliged to sort packaging waste, to clean them up and carry them to assigned recycling stations. Manufacturers are not required to pay consumers for this effort, despite their responsibility for meeting targets of legislation (Hage 2007).

Waste collection produces several types of environmental impact from production and use of different types of bags and containers, use of transport vehicles and construction, maintenance and demolition transfer station. It was noted that the acquisition of a particular type of waste container by an institution corresponds in most of the cases to economical or aesthetic criteria, but never to Environmental Protection (Rives et al 2010). This aspect is very important in order to propose an optimal system for collecting waste from households.

As can be seen from selective waste collection models described above, in European Union (EU) the tendency is to collect waste at source, because they are clean, for recycling. In this respect, a good option for urban areas (metropolitan area along with the case) can be the recycling machines.

Developing an integrated waste management system must be adapted to the social and economic climate in the area. System design and development must be based on an analysis, evaluation and implementation of a pilot system for selective waste collection and treatment methods that address both municipal solid waste and special waste (e.g. hazardous waste). The entire waste generated stream should be examined, and the possibility of separation at source and recycling of household waste, especially fractions that need special attention such as garden waste, bulky waste, portable batteries, household hazardous waste etc (Papachristou et al 2009).

The integrated management system for urban waste proposed by the authors in base of the European studied models, existing facilities and recovery targets for Cluj County includes more steps as seen in Figure 3.

For the selective waste collection in urban areas a combined model is proposed, that includes a selective collection of glass, plastic cups and cans by using automated recycling (purchased by producers of packaging). These machines can be equipped with a system to return a voucher that is redeemable at a retailer partner. Such people will be interested in exploiting these types of waste instead of being thrown at random in the environment. Glass, PET, cans and paper waste goes directly to recyclers. Recycling machines can be used both for indoor and outdoor, to four types of recyclable packaging: PET, glass, cans and plastic cups. It can be equipped with: roller or grinding mechanism to decrease the volume of packaging; module of sorting, packaging to be collected for groups of materials; logo recognition device that allows the wrapping materials by recognizing the logo; GSM mode signal which is made using SMS alerts if the collection bags are filled or if there is any malfunction at the machine (Recycling machines).

Given that, packaging manufacturers are responsible for organizing the selective collection of packaging waste, recycling machines would be purchased by them. In this case, the costs for municipalities for the selective collection of these waste categories would decrease significantly and no longer need to set up special collection centers for recyclable waste categories listed.

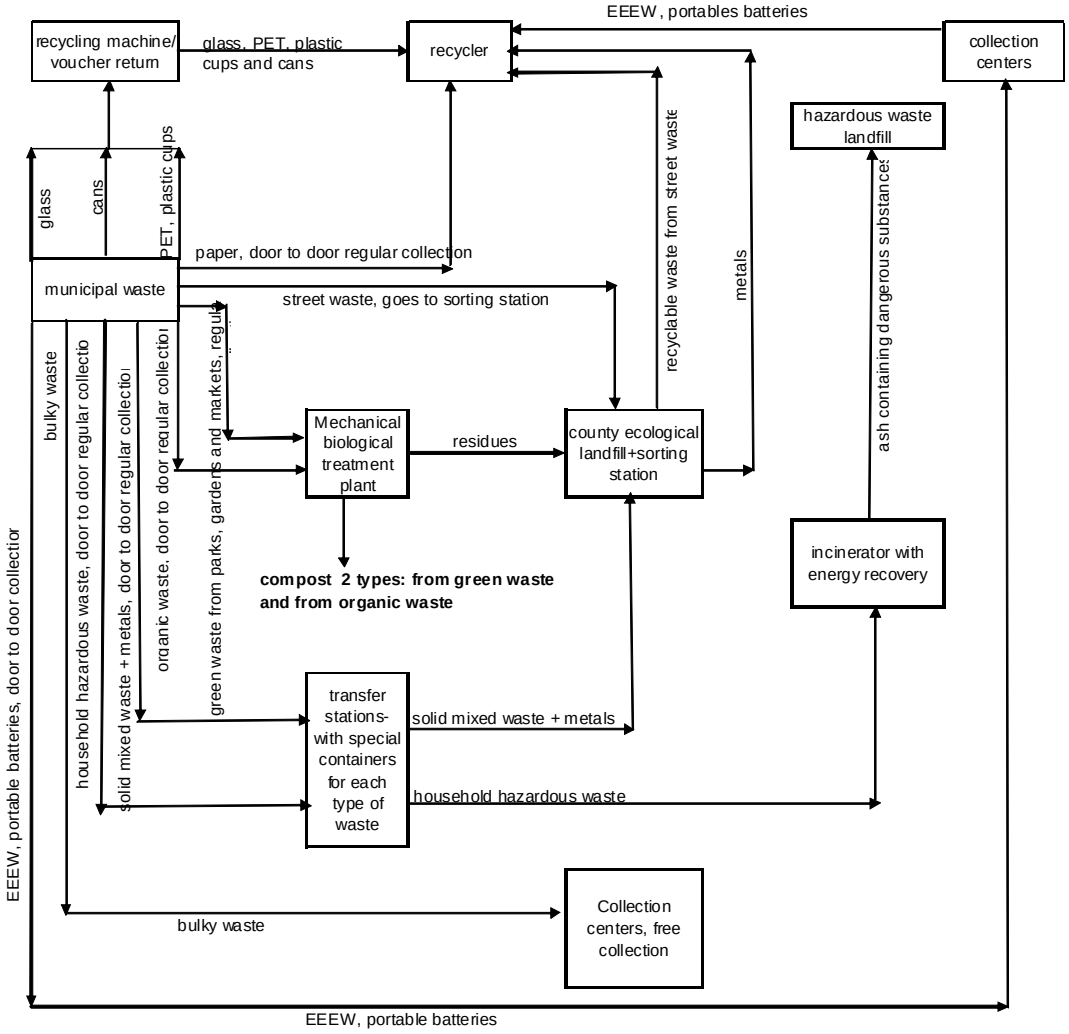

Figure 3. Integrated management system for urban waste proposed in Cluj County.

Implementation of a periodically selective collection system at source (from door to door) with 5 bins for waste paper, mixed solids and metals, hazardous waste, organic and/or green (where applicable) and EEEW and portable batteries, needs to be correlated with the frequency of waste removal by the sanitation operators. Although expensive at first, believe that this variant of selective collection is better than implementing a collection system with fewer fractions. At the first case can get clean waste that can be recycled in its entirety. The organic and green waste (biodegradable) will be turned into compost, thus avoiding their storage.

Waste paper collected at source and regularly raised will be transported directly to recyclers.

Bulky household waste will be taken by each citizen to special collection centers where it will be received for free. Although the objectives of the County Waste Management Plan is under implementation the biennial collection of bulky waste from households, consider more appropriate setting up special centers for the acquisition of such waste to prevent illegal dumping of such waste in various places due to lack of storage space.

Mixed solid waste with metals and hazardous waste will be collected periodically and then transported to transfer stations (due to large distances to deposit or incinerator).

Household hazardous waste will be transported from transfer stations and then to the incinerator with heat recovery, and mixed waste and metal will be transported to the ecological county landfill where will be an ecological station for sorting ferrous and

nonferrous metals. From there the metal will be sent in turn to recycling. Ash from the incinerator containing dangerous substances will be sent to a landfill for hazardous waste.

Electrical and Electronic Equipment Waste (EEEW) and portable batteries will be collected periodically from source to be taken to special collection centers and then recycled, because the citizens doesn't enough cooperate to take such waste at specialized centers or stores. In the case of all portable batteries, most of them go to the landfill, thus contaminating the soil and groundwater with heavy metals.

Organic waste, as well as green waste from parks, squares and gardens will be taken directly to a Mechanical Biological Treatment Station (MBTS), where they will get two types of compost that can be sold later. Residues from MBTS will be transported to the ecological landfill.

Street waste will be sent directly to the county ecological landfill where it will be sorted. Recyclable waste obtained by sorting (paper/cardboard, plastic, ferrous and nonferrous metals), will be sent to recyclers. For each type of waste, the municipalities must provide containers or bins, colored and marked accordingly.

In urban areas campaigns to collect recyclable materials can be organized in schools (especially paper) to raise students' awareness and obtain an income.

For the textile waste, housing associations or citizens may ask to be collected in a door to door system by charitable organizations.

To gain an insight into the level of acceptability of the proposed model of an integrated waste management system, a survey conceived by the authors was conducted on a sample of 50 persons in urban areas, with different ages and incomes. The questionnaire was applied in November 2010, in the city of Cluj-Napoca by the authors.

The questionnaire includes 14 questions from which 12 specific questions about wastes. Out of the 12, one question had more response options, other 2 have requested had an exact response, and the other 9 had the choice: yes, no and I do not know.

The results are presented in the charts below.

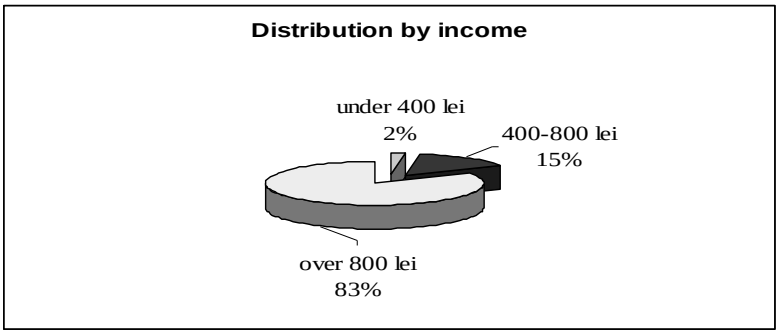

Figure 4. Distribution by income.

As can be seen in Figure 4, the income distribution shows that the average earnings per family are 800 lei, for almost the whole group.

In Figure 5 is apparent that the age of the subjects was relatively proportional elected for five age groups: 9 persons between 21-30 years, 14 persons between 31-40 years, 11 persons between 41-50 years, 8 persons between 51-60 years and 8 persons over 60 years. At questions no. 6, 7, 8, 9, 10, 11, 12, 13 and 14 the most of the people have answered "yes", the responses by age is also proportional.

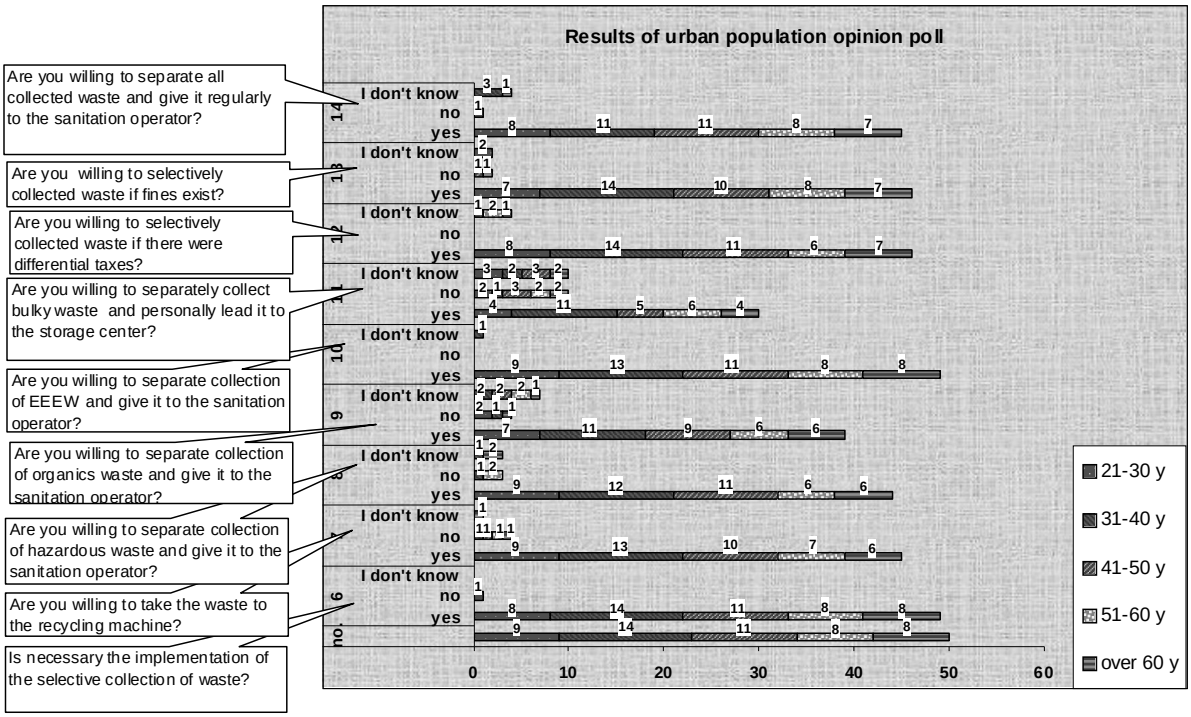

Figure 5. Cumulative results of the poll.

Results and Discussion. Problems identified in the current waste management from urban population of Cluj County are as follows:

- The packaging waste selective collection of the current system can not achieve the packaging targets, so new investments are necessary.
- The legislative provisions in force stipulate that municipalities should ensure the selective collection of municipal hazardous waste, but this is not implemented in any locality, except for EEEW collection points.
- Concerning the biodegradable waste, it is not carried out a separate collection as required by the national and European legislation and does not exist treatment plants for it, for these reasons the above objectives are problematic.
- There are still four non-compliant deposits, causing a negative environmental impact and the construction of a county landfill is still being planned.
- Recycling is at a very low level, although there are recycling companies in the area. The selective collection at source of the recyclable waste is missing. Companies do not accept sorted waste after the mixed recyclable collection, because it is mixed with waste fractions Specific objectives for recovery/recycling of packaging waste will not be met, if an effective system of integrated waste management will be not implemented, based on selective collection at source.
- Sanitation services are not properly organized in most of cases, even efforts are made to a selective collection by pilot projects, waste collected with high delays and there are cases in which the waste is mixed into the containers
- Public awareness about the selective collection of the recyclable packaging waste is little, local authorities were not sustained and continuous efforts in this regard.

It is worth mentioning the presence of heavy metals in landfill areas (ramps) soils, so in the Pata – Rat area, exceeded the Ni concentrations in soil (REPA, Data base, 2009).

In Campia-Turzii Power Pack area, the exceedances for Zn, Cu, Pb and Ni were recorded from normal values. In the Power Pack Gherla area, the exceedances for Zn, Cu, Pb, Cd and Ni were found to normal values (REPA, Data base, 2009).

Soil quality in Somes Dej dump area is affected by excessive concentrations of Zn, Cr, Cu and Pb, and the soil quality in Cesom Dej dump is affected by overruns concentrations of: Cr, Cu and Pb (REPA, Data base, 2009).

The model of an integrated waste management system is a complex one that meets the existing needs. The integrated waste management plan which will be implemented in Cluj County has specifies the building of a landfill and three transfer stations and a Mechanical-Biological Treatment Station.

Cherubini et al (2009) shows that storage in landfills is the worst option on the waste management, and the waste recycling and incineration with energy recovery has significant environmental good effects. If a choice should be made between different options, even incineration is a better alternative than storage in landfills, in terms of environmental impact.

The analysis of the questionnaires results shows that the population considers that a timetable for different categories of waste collection is necessary. In this sense the cooperation between the sanitation companies (or the local authorities) and the citizens (in the case of private houses) or the owners association (in the case of blocks of flats) is absolutely necessary. Through these collaborations, also the residents may be informed about the need of a waste selective collection.

The proposed selective collection model addresses both needs and desires of the county population, reflected through questionnaires submitted. In the case of introducing of a differentiated charges system by local government for the collection of waste, the analysis of the questionnaires shows that the people are willing to adopt the system.

The differentiated charges system should be completed with a penalty imposed system by the control bodies of municipalities. Public reaction to the fines system is a positive one, as shown in the poll.

The analysis responses to questions no. 3, 4 and 5 show that people doesn't know the present situation of waste management in the area. The answers to these three questions shows that they don't understand how the local waste collection works, which the number of existing storage facilities, and how many warehouses or storage facilities were closed in that area.

The central results of the questionnaires applied to 50 people with different ages and incomes in urban areas, have shown that the population is not sufficiently informed about managing household waste.

Information and awareness of the people can be through regular briefings in the newspapers, on local television stations, and through posters and flyers displayed in crowded places (ex. bus stations, gas stations, stores). Another way may be achieved through information campaigns in schools held quarterly or biennial organized by municipalities' representatives in 2 or 3 places from each district of the cities. This can be an opportunity to obtain feedback and suggestions from residents, for the improvement of the collection system.

Conclusions. Given the existence of a faulty waste management system in the urban areas of Cluj County, the paper tries to propose a waste management integrated model system.

From the current waste management system above linked to targets and objectives set in the national law, it is noted that in the case of the following objectives, there were delays to:

- the recovery of the good potential of the waste
- building the 3 transfer stations
- building the county ecological landfill
- implementation of the selective waste collection
- reducing the amount of biodegradable waste reaching the storage
- achieve targets for recycling and recovering packaging waste, wood, plastic
- selective collection of the hazardous waste from household waste
- implementation of the biennial collection of bulky waste

From the centralized results of a questionnaires sample of 50 persons from urban area with different age and incomes, it was observed that the population is not sufficiently

informed about waste management in the area, as shown the questions no. 3, 4 and 5. For this reason awareness about this issue is very low. Moreover, as shown in the poll, the people are very receptive to the problem of waste management, considering that it is necessary to implement an efficient and functional system, being prepared to selectively collect the different types of household waste and to cooperate with the local authorities and sanitation operators to the efficiency of this system.

In the analysis of responses to question no. 11 relating to transport bulky waste to specialized centres, we should consider the request call option of sanitation operator, to pick up the waste and transport them to specialized centres, not necessarily twice a year as proposed the County Waste Management Plan. Related to biodegradable waste, it is necessary to create a compost market through contracts between municipalities and companies which can use compost, and through studies for finding new uses for compost.

About the EEEW and portable batteries which has a collection system in stores and specialized collection centres, according to population responses in questionnaires, they should be willing to selectively collect (currently through the existing collection the rate is very low) if the sanitation operator regularly rose at home.

Acknowledgements. This work was carried out with financial support of the project EURODOC "Doctoral Scholarship for performance in European research", funded by the European Social Fund and the Romanian Government. We are grateful to Mr. Prof. Dr. Laurenţiu Călin Baciu for his aid and guidance during this work.

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Received: 13 June 2011. Accepted: 26 July 2011. Published online: 26 August 2011.
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How to cite this article:
Popiţa G. E., Popovici A., Haţegan R. M., 2011 Developing a municipal urban waste management integrated system in Cluj County. AES Bioflux **3**(2):194-205.