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WASTE GLASS MANAGEMENT FOR BAKIRKOY MUNICIPALITY: A CASE STUDY

Anıl PIR*[1], Ömer APAYDIN[2]

[1]*T.C. Bakırköy Belediyesi, Çevre Koruma ve Kontrol Müdürlüğü, Bakırköy-İSTANBUL*
[2]*Yıldız Teknik Üniversitesi Çevre Mühendisliği Bölümü, Davutpaşa-İSTANBUL*

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ABSTRACT

District municipalities in metropolitan cities are in indispensable position on separate collection of wastes, collecting waste from site and transporting those to disposal or recycling facilities in Turkey. By building correct and effective system of collecting wastes, separately collected waste fraction and quality of these wastes will increase moreover both costs of collecting from sites and separating in facilities will be lowered. In the country, waste glasses are collected from door to door with other recyclable wastes by many municipalities. In case of collection and separation of waste glass together with other packaging wastes, occupational accident risks increase. On the other hand, if they involved in municipal wastes, waste glass is being embedded into disposal areas and becomes harmful for habitat. Bakırköy, a district of İstanbul city has 220,663 population and production of municipal solid waste is 326.5 tones daily in it. 5 % of these wastes are composed of glass. Within the scope of this paper; legislations about recyclable waste management in Turkey are examined, commonly used waste collecting systems are researched, existing equipment locations are optimized and by determining needed equipments to collect waste glass with "stationary container system" from the town they are marked onto the map considering accessibility by the local community, with CAD (Computer-Aided Design) software. Consequently, it's been deduced that 95 new collection locations should be added out of 45 old ones. Furthermore, the application has been monitored for 18 months. By increasing the number of waste glass bins and planning their dispersion on site, recovered glass amount have raised outrageously, on the other hand people's interest and consciousness about recycling of waste glass has begun to increase as well.
Keywords: Municipal solid waste, recycling, waste collecting systems, waste glass, waste management.

BAKIRKÖY İLÇESİNDE ATIK CAM YÖNETİMİ: BİR VAKA ÇALIŞMASI

ÖZET

Türkiye'de atıkların türlerine göre ayrılması, yerleşim yerinden toplanması ve bertaraf ya da geri kazanım sahalarına taşınmasında büyükşehirlerde ilçe belediyelerine önemli görevler düşmektedir. Doğru ve etkin toplama sistemlerinin kurulması ile ayrı toplanan atık miktar ve kalitesinde artış olacağı gibi toplama ve ayırma maliyetleri de asgariye inecektir. Ülkede bir çok belediyede atık camlar diğer atıklar ile birlikte kapıdan kapıya toplanmaktadır. Atık camlar, diğer atıklar ile birlikte toplandığında ve aynı tesislerde türlerine ayrıldığında çeşitli kazalara sebep olabilmektedir. Kentsel atıkların içerisinde bulunan camlar ise atık depolama sahalarında gömülerek bertaraf edilmekte, uzun yıllar bu alanlarda bozunmadan kalarak doğaya zarar verme potansiyeline sahip olmaktadır. İstanbul ilinin Bakırköy ilçesi 220,663 kişilik nüfusa sahiptir ve ilçede oluşan günlük 326,5 ton kentsel katı atığın % 5'i camlardan oluşmaktadır. Bu makale kapsamında; ülkemizde geri dönüştürülebilir atıkların yönetimine dair yürürlükte olan mevzuat irdelenmiş, atıkların toplanmasında yaygın olan sistemler araştırılmış ve Bakırköy ilçesinde atık camların toplama sistemine ilişkin "sabit konteynır ile toplama" için gereken ekipman belirlenip, cam kumbaralarının halk tarafından ulaşılabilirliği dikkate alınarak ilçede cam kumbarası yerleştirilmesi gereken yerler CAD (Computer-Aided Design) yazılımı ile harita üzerinde belirlenmiştir. Çalışma sonucunda, ilçede mevcut olan 45 adet cam toplama kumbarasına 95 adet yeni toplama noktası eklenmesi gerektiği hesaplanmıştır. Daha sonra uygulama 18 ay süresince takip edilmiştir. Sahada toplama ekipmanlarının sayısının artırılması ve dağılımlarının yeniden düzenlenmesi ile geri kazanılan atık cam miktarı önemli artış göstermiş, diğer yandan ilçede yaşayan halkın atık camların geri kazanılması hakkındaki ilgi ve duyarlılığı da artmaya başlamıştır.
Anahtar Sözcükler: Kentsel katı atık, geri dönüşüm, atık toplama sistemleri, atık cam, atık yönetimi.

* Corresponding Author/Sorumlu Yazar: e-mail/e-ileti: anilpir@hotmail.com, tel: (507) 500 23 75

1. INTRODUCTION

In Turkey, as a developing country, averagely 1 – 2 kg of waste is generated daily, per capita and 25 % of these wastes are appropriate to be recycled as known. Averagely, 14,000 tons of waste is removed by embedding into waste storage sites, just in Istanbul city. In Istanbul, including scrap and excavation wastes, 1.16 kg of waste is generated daily, per capita. Nevertheless, according to 29 of all (39) municipalities in the city, which have declared their outputs properly, recycled materials per day is only 34 g/capita [1].

Packaging wastes, except production wastes, are defined as selling, secondary and transportation packages' wastes whose lifetime expire and which had been used for presentation or transportation of a product to consumer or end user, including reusable materials [2].

Glass is a transparent material formed by melting a mixture of materials such as silica, soda ash and $CaCO_3$ at high temperature followed by cooling during which solidification occurs without crystallization [3]. Glass may be produced as flat glass and in many forms used in materials like test tubes, bulbs etc. and as packaging material also that may be colorful or not.

Waste glass can be recovered as secondary raw material itself by crushing and melting to mix with other raw materials or in ways like using for producing concrete roads and as aggregate recycled asphalt coating, in cement mortar and concrete, granular base or filling if crushed into sand size similar to natural sand [4].

In case of collection and separation of waste glass together with other packaging wastes, occupational accident risks increase. On the other hand, if they get involved in municipal wastes, waste glasses are being embedded into waste storage sites and become harmful for habitat. For these reasons, in cities, as a feasible way, it's necessary to set a different collecting system from other waste types for waste glass.

Many systems like door-to-door or building-to-building collection, stationary or mobile containers, collection in waste pooling sites are different alternatives which could be put into effect according to sort of waste and collection costs.

In Turkey, the responsibility of collecting and recovering packaging wastes and other recyclables is given to district municipalities, in metropolitan cities. In this case, district municipalities have to make their systems for collecting and recovering these wastes in a regular way.

Bakırköy, a district of İstanbul city, has 220,663 population. From the district, except wastes collected separately, averagely 326.5 tones of household waste are generated daily according to 2012 data. With reference to a characterization study, municipal solid waste include approximately 5 % glass and 25 % other recoverable wastes [5]. To the characterization data as it's understood both consciousness on recycling around the citizens and recycling rates are insufficient.

In Bakırköy, packaging wastes are collected with door-to-door system. Mentioned system necessitates high effort while collecting. Both labor and time run to waste. Moreover, low interest on the subject seems to arise from irregularity and difficultness of collecting.

Within the scope of this study both currently available national legislations and literature studies on waste collection and recovery were examined by taking local circumstances into consideration.

Hence, it's aimed to determine needed equipments to collect waste glass by "stationary container system" from the town and disperse them to optimum places; they are marked onto the map considering accessibility by the local community by CAD (Computer-Aided Design) software.

Once the planning work was done, needed equipments have been placed to envisaged locations and the system had been monitored for 18 months as recording and analyzing recycled waste glass amount and opinions of citizens to see the success of new system. Their locations were also optimized through the requests of users regularly.

2. LEGISLATION ABOUT ENVIRONMENT AND RECYCLABLE WASTES IN TURKEY

In Turkey, the most comprehensive legal infrastructure on the environment was formed in 1983 with the law no. 2872, "Environmental Law". This law has been reformed 13 times with the purpose of both contemporary needs and adaptation to acquit within European Union full membership process. At last, it has brought in compliance with to-day conditions by revising its 40 clauses. The law authorizes Ministry of Environment and Forestry (now Ministry of Environment and Urbanization) to make all the regulations about waste management in the country except some wastes from several special applications (military, radioactive, nuclear wastes and stone pit wastes) [6]. The ministry, made the first regulation about waste management named "Solid Wastes Control Regulation" in 1991. Thereafter, new regulations have been made to form special management systems by type of different wastes.

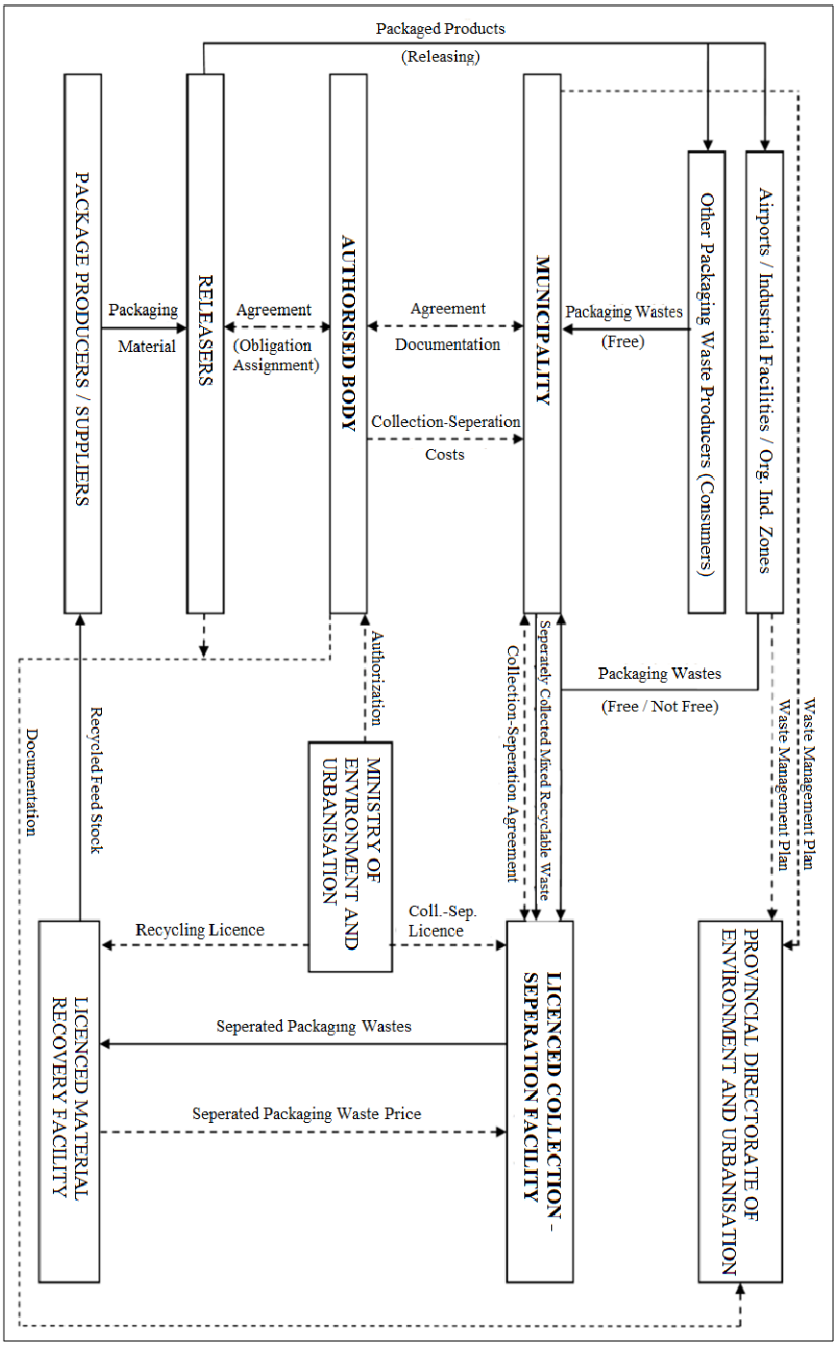
To legal infrastructure, there are two approachments for management of wastes. The first of these is to classify them according to their hazardousness, given in the list inside of "General Principles of Waste Management Regulation". On the other hand second approachment is classify them by their species which require a different system while being collected, transported, recovered or disposed because of their physical, chemical or economical specialties whether they are hazardous or not. The management systems of frying vegetable oil wastes, waste electrical and electronic equipments, medical wastes, batteries and also packaging wastes have been differed from other wastes by this approach.

Although packaging wastes' had to be separated from others due to Solid Wastes Control Regulation previously, the first regulation was made about these wastes' management solely in 2004 as "Packaging and Packaging Wastes' Control Regulation". As of this date, the regulation have been changed completely twice (2007 and 2011) and made several changes in it. Current regulation is "Packaging Wastes' Control Regulation", was published in 2011.

In accordance to "polluter pays" principle in Environmental Law, expenditures of collection, transportation, separation in MRF facilities and recovery of packaging wastes have to be afforded by releasers of products with its package than they have to document these payments to the ministry. For this purpose, "releasers" can get together and be an "authorized body", which doesn't seek profit, by taking the necessary permission from the ministry. In Turkey, there are 2 authorized bodies currently, "ÇEVKO" and "TÜKÇEV". Releasers can cooperate with one of these to fulfill the documentation obligation as paying the price in proportion to sort and amount of packages they've released.

For the recovery of recyclable wastes, district municipalities in metropolitan cities have indispensable position. They have to set the separate collection system and raise awareness of recycling by making a packaging waste management plan. On the other hand packaging waste producers, out of some exceptions, have to give these wastes to the municipality for free.
As municipalities can directly execute an agreement with releasers and approve the documentation of these, they can also prefer to make it with authorized bodies. Moreover, they can prefer to assign a professional company for collecting and separating recyclable wastes in its facility.

The scheme of management of packaging wastes in Turkey is given in Figure 1; ongoing tripartite system in Bakırköy has shown as representational in Figure 2.



[*] *The relative clause in the regulation as to industrial facilities, organized industrial zones and airports may give their packaging wastes to municipalities with payment has been taken out from it a by court decision.*

Figure 1. The scheme of management for packaging wastes

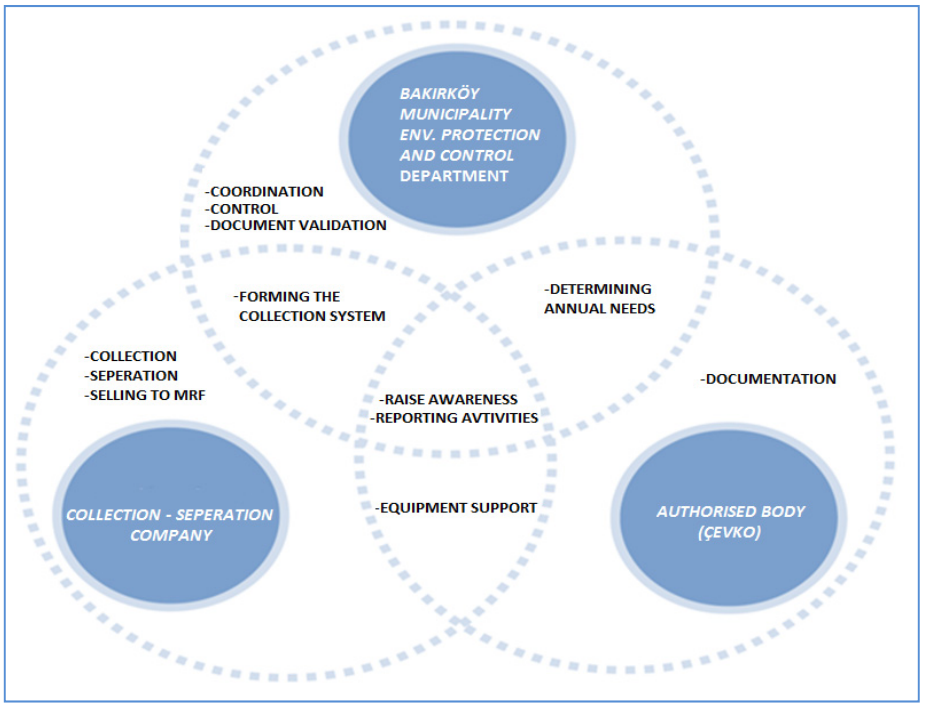


Figure 2. Ongoing tripartite system for managing packaging wastes in Bakırköy District

3. SEPARATE COLLECTION SYSTEM OF WASTE GLASS WITH STATIONARY CONTAINERS

3.1. Widely Used Waste Collection Systems and Former Collecting Method For Packaging Wastes in Bakırköy

There are many proven systems used for collecting and transporting wastes in the world. The most preferred systems are; collection from door-to-door, building-to-building, kerbside, handcart, pooling sites, public bins, stationary containers or mobile trailers, dumpsters, public litter baskets, underground waste cells and collection with enouncing (bell collection) [10, 11].

The main facts must be regarded while deciding the right collection system are;

- Sort of the waste
- Source of the waste (industrial zone, residential area, trade center etc.)
- Accessibility
- Technical necessity or legal restriction

Waste pooling site is a centralized collection point typically located on public property no more than a specified distance from any waste generator [7]. Although most developed countries have this type of collection points in their cities, legal infrastructure hasn't been formed for this type of system yet in Turkey. Nevertheless, pooling sites have been set up in several cities. However, because of the lack of available lands inside metropolitan cities like İstanbul, it's very hard and costly to find suitable places for this type of sites.

Mobil trailer system is widely used for collecting recyclable wastes from highly productive places as especially shopping malls or industrial facilities but it's useless inside a residential area.

In Turkey, many district municipalities use one of "door-to-door", "building-to-building", "kerbside", "public bins", "stationary containers", "mobile trailers", "enouncing (bell collection)" collection systems or together with more than one to collect packaging wastes. However; some recyclable wastes like paper, cardboard, plastic, metal are being collected by handcarts illegally.

At stationary container system, little waste bins or containers stay in certain locations and are dumped into the compactor fixed on the collecting vehicle when they are filled. For hand loaded compactors, generally 0.075 – 0.2 m^3 containers are used while 0.6 to 8 m^3 containers could be used for mechanically loaded ones. When the compactor gets filled, the vehicle turns back to discharging area. After discharging, vehicle continues collecting from where it took the waste at last [8]. This system is widely used for collecting municipal solid wastes in İstanbul.

There are a wide variety of collector containers designs. The system is quite effective in collecting costs and work force especially compared to door-to-door, building-to-building and kerbside collection.

In Bakırköy district, most amounts of all sorts of recyclable wastes was being collected with "door-to-door", "building-to-building" and "kerbside" collection types before this study. Generally, these types of collection systems are used for collecting municipal solid wastes for the sites in which streets are as narrow as containers can't be placed on or collection vehicles can't go into them. Together with this, there were several stationary containers for recyclables, placed as unplanned on site.

Because of the low effectiveness and efficiency and especially the very high occupational risks for servicing personnel, it's been aimed to give up "door-to-door" as collecting waste glass and generalize the stationary container system all over the district with effective management of waste glass recycling bins.

3.2. Analyzing Available Situation – Locating And Mapping Available Waste Glass Collecting Equipments On Site

3.2.1. Existing Collection Points

In Bakırköy, separately collection of recyclable wastes studies started in 2001 as a civil society initiative firstly. When relevant regulations were made, operations of the municipality have been harmonized through them.

At the place where is being used as packaging waste intermediate storage site currently in Osmaniye neighbor, was firstly used as collection-separation facility but thereafter collecting and separating works subcontracted to different companies under control of the municipality. Both municipality and subcontracted companies have located various equipments on the site but just a few of them came until today as usable.

The locations of the equipments, their conditions, filling times and other collection points were only known by collecting personnel. Mentioned circumstances cause lack for collecting waste from bins regularly. Unplanned locations of waste glass bins would threat human health, environmental and traffic safety, on the other hand their lifetimes get shorter. In Figure 3 some equipments' images which is worn as it can't be used, threatening human health and traffic safety are shown.

Figure 3. Images of some waste glass bins in bad situations *(a): worn as unsuitable to use (b): threatening traffic safety (c): threatening health*

For collecting waste glass with mentioned stationary container system, firstly variously available 55 waste glass bins available on 45 locations on the site were chained with the forms prepared formerly (Figure 4) and determined their conditions. These collecting points were numbered from "01" to "45".

3.2.2. AutoCAD® Software, Mapping and Layers

After seeing current situation of available points, a list of the equipments and a map shows these on it have been generated. For mapping studies AutoCAD® software was used.

Computer Aided Design And Drafting/CADD means designing and drafting through the instrument of computer. Shortly, it's being said CAD (Computer Aided Design) [9].

CAD systems have been used since 1964. From this date many designing software have been developed. From architecture to machinery, electronic equipments to advertising, mapping to medicine they've been used for any subject require drafting. It's been developed to fulfill the needs on these subjects and become an industrial standard [10].

AutoCAD® is accepted as an industrial standard, being used widely in every designing and engineering field. There are over 3,900 applications approved for various disciplines and it's being studied at universities. AutoCAD® is trusted software for its users because of its ease to use, multidisciplinary, publishing in 17 languages and sufficient marketing worldwide [10]. There are also mapping among its engineering applications.

As researching materials; 1/8000 scaled Bakırköy map with high resolution (16,534 x 11,812 pix.), taken from Istanbul Metropolitan Municipality and AutoCAD® software released by the company named Autodesk INC., instruction book of this software, various ancillary documents, PC hardware and peripherals were used. The be-all and end-all for choosing this software were vector plotter logic of it and it allows for working with different layers.

District map, district and neighbor borders, roads, existing glass containers, needed glass containers, their three different simulated circular usage areas (with 100m, 250m and 500 m radius) to optimize their locations and determine needed equipments further and barriers which cut the mentioned areas were used as drawing layers.

EQUIPMENT FORM

C027

EQUIPMENT	☐ Recycling Container	☐ Waste Glass Bin (Square)
	☐ 3 Partitioned Waste Bin	☐ Waste Glass Bin (Bottle Shaped – 660 L)
	☐ 4 Partitioned Waste Bin	☐ Waste Glass Bin (Bottle Shaped – 1200 L)
	■ Waste Glass Bin (Round)	☐ Waste Glass Bin (Bottle Shaped – Mini)
	☐ Other (.....)	
NUMBER	1	
LOCATION	Yeşilköy Mah. Intersection of "Cekmece Street"and "Murat Cankat Street"	

Comment the facts below from 1 (Worst) to 5 (Best)					
Human Safety	1- ☐	2- ☐	3- ☐	4- ☐	5- ■
Accessibility by citizens	1- ☐	2- ☐	3- ☐	4- ☐	5- ■
Accessibility by coll. trucks	1- ☐	2- ☐	3- ☐	4- ☐	5- ■
Traffic Safety	1- ☐	2- ☐	3- ☐	4- ■	5- ☐
Equipment's Safety	1- ☐	2- ■	3- ☐	4- ☐	5- ☐
Visual Adaptation	1- ☐	2- ☐	3- ☐	4- ■	5- ☐
Physical Situation of Equipment	1- ☐	2- ☐	3- ☐	4- ☐	5- ■
	1- ☐	2- ☐	3- ☐	4- ☐	5- ☐
	1- ☐	2- ☐	3- ☐	4- ☐	5- ☐
	1- ☐	2- ☐	3- ☐	4- ☐	5- ☐
	May be added different considerations				
Loaded Waste to Capacity Ratio	% 10				

Additional Info (Comments and Thoughts) –

Control Date : 27/03/2013

Controller : Anıl PIR

Signature

Figure 4. An example of the equipment forms prepared

Circles in which have existing containers into their centers with 100, 250 or 500 m radius, had been added onto the map to see the current dispersion of collecting equipments.

By specifying simulated areas for glass bins, their locations were optimized and new locations for the further bins were determined.

In Figure 5, an example of mapping study is shown.

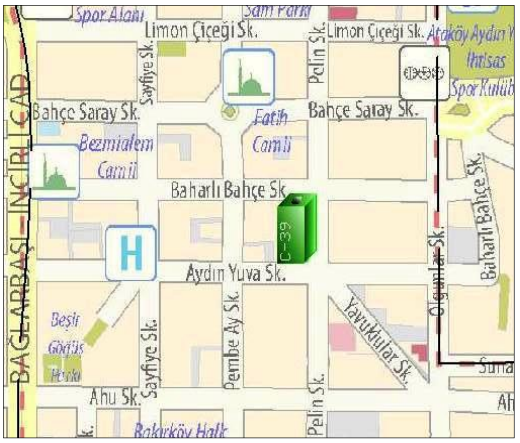


Figure 5. An example from mapping

As the result determining available conditions study, 55 bins on different 45 locations were listed. A list of numbers of these formerly added equipments in different neighbors are shown in Table 1. As clearly seen in the table, collecting equipments in Bakırköy were insufficient and unplanned.

Table 1. Distribution of available waste glass bins at the beginning of the study

Neighbor	Population	Existing Glass Bins	Person Per One Equipment
Ataköy 1.	1,701	2	850
Ataköy 2-5-6.	12,278	1	12,278
Ataköy 3-4-11.	7,986	3	2,662
Ataköy 7-8-9-10.	22,387	8	2,798
Basınköy	5,769	3	1,923
Cevizlik	5,299	0	-
Kartaltepe	38,535	6	6,422
Osmaniye	23,954	0	-
Sakızağacı	8,574	0	-
Şenlikköy	27,913	9	3,101
Yenimahalle	7,108	0	-
Yeşilköy	24,165	10	2,416
Yeşilyurt	6,874	5	1,375
Zeytinlik	5,488	0	-
Zuhuratbaba	22,632	6	3,772
TOTAL	**220,663**	**55**	**4,012**

3.3. Determining Needed Locations and Numbers of Waste Glass Bins

Within the scope of this study it's been seen that most of the citizens couldn't attain any equipment to leave their waste glass. For determining additive locations, simulated circular areas that has a waste bin in its centre and whose radius are 100, 250 and 500 m separately to symbolize its usage area were created for every waste glass bin one by one as the same way used for optimizing old equipments' locations. If a circle was cut by main roads, railways or other barriers to reach a bin, than the circle has been exploded for taking unreachable area out. By this way different locations and usage areas have been visualized. This study was finished throughout all the residential and trading area in the district. Because of the airport in Yeşilköy neighbor has its own packaging waste management plan, the study hasn't been carried out for its area.

Regarding the situation in Table 1, calculated numbers of needed waste glass bins for different simulated usage areas are shown in Table 2 and mapped via AutoCAD® software.

Table 2. Needed waste glass bins for different usage areas

Radius of Simulated Circles for Usage Area, (m)	Simulated Usage Area, (ha)	Needed waste glass bins, (number)
100 m	3.14	**519**
250 m	19.6	**95**
500 m	78.5	**14**

3.4. Monitoring the Application

While carrying out the optimization, mapping studies and action on site, citizens' requests and complaints about collection of waste glasses and separately sold waste glass amount to material recovery facilities (MRFs) have been recorded for 18 months.

Between July of 2012 and December of 2014, effectiveness of the new system reviewed by monitoring the monthly waste glass amount sold to MRF facilities. Graphic data given in Figure 6 shows the amounts before and during the progress of the study in the district.

During the same 18-month period; requests, suggestions and complaints of the citizens who get the service from Bakırköy Municipality, about the waste glass collecting system were recorded. By this way it's been aimed to understand the acceptableness of new system from the people who use it. Positive or negative opinions of the citizens directly about the collection system in the district are given in Figure 7. Feedbacks such as acknowledgements for new bins placed near them, suggestions about waste bin numbers to be increased or informing about the some other places to be laid more bins were regarded as positive opinions, while complaints like "waste glasses, just like others, should have been taken from houses" as negative ones made directly to the system.

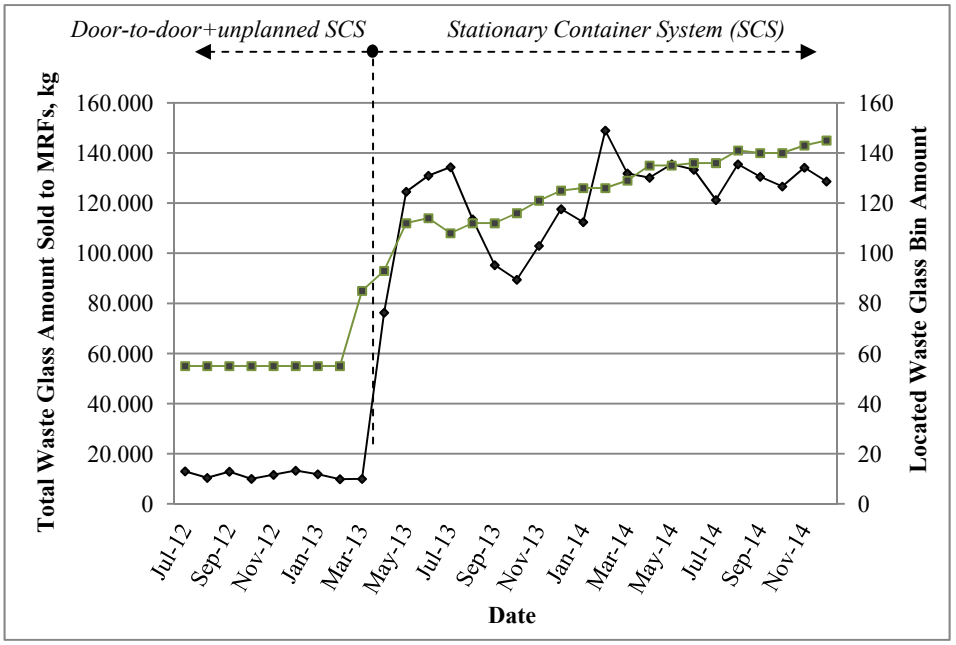


Figure 6. Total waste glass amount sold to MRF facilities; before, during and after the study

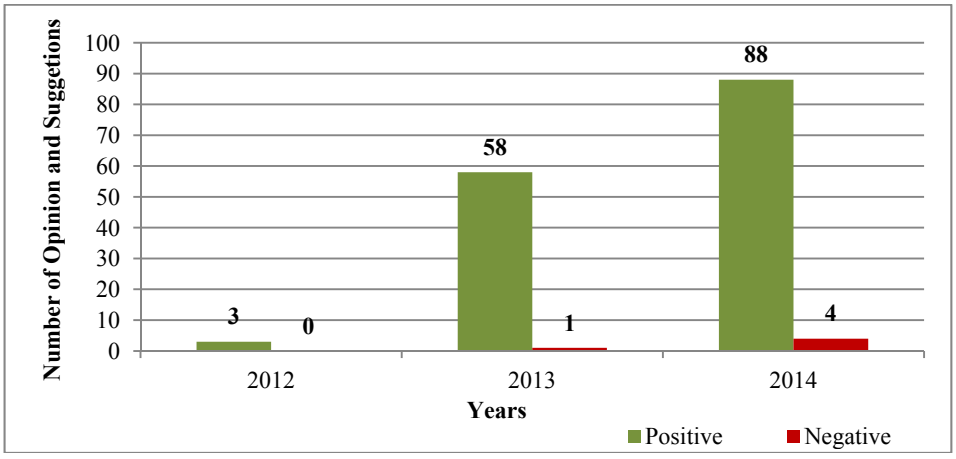


Figure 7. Opinions and suggestions of the citizens about collection system of waste glass

After beginning of collecting waste glass only from the stationary containers, March of 2013, also notifications arrived from the citizens about the bins which require to be emptied, have been recorded and given in Figure 8.

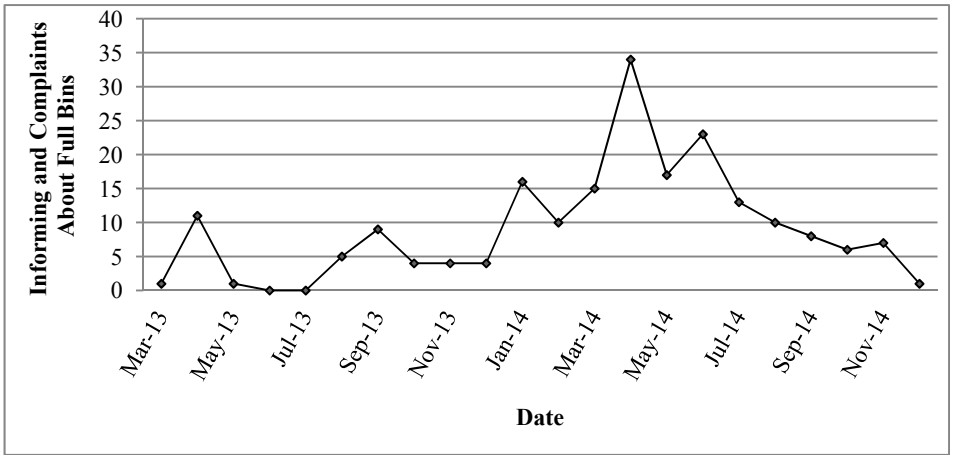


Figure 8. Numbers of people's notifications about filled bins after beginning of collection of waste glass only from the stationary containers

5. CONCLUSIONS AND DISCUSSION

Regarding the mapping study within the scope of this paper, usage areas with 250 m radius for waste glass bins, have been determined to be most feasible for present financial conditions of the studied municipality. Based on this, for collecting waste glass effectively, available 45 stationary container locations were optimized and 95 new locations have been added on site. Within this study, 250 m usage distance had been defined as objective for waste glass bins.

By given data of waste glass amount sold to MRF facilities; before, during and after the study in Figure 6, it can be seen that recycled waste glass amount have increased outrageously by optimizing old locations and just after from beginning placing more waste glass bins on the site.

Depending on the number of opinions and suggestions of the citizens, recorded about collection system of waste glass given in Figure 7, by adding new containers closer to them, people's consciousness about recycling of waste glass have been increased. From the increasing number of opinions arrive to the municipality, it's inferred that people started to concern more about recycling waste glass much more year by year.

Nevertheless, as a disadvantage of stationary container system, it seems quite reactive to probable troubles in collecting. Complaints recorded as monthly and shown in Figure 8, show that there was a lack of collection timing during the first half of 2014, especially in April of the year. So, collection route planning and optimizing studies carry an indispensable importance on practice using stationary collecting system.

Same optimizing studies which have been done for waste glass, as a guide, can be applied to other wastes which are collected with stationary containers such as plastics, metals, frying oils etc. Optimizing collection points and vehicle routes can both decrease waste collecting costs significantly. Moreover fuel emissions will decrease also.

Collecting recyclable wastes at its source with stationary container system seems as an effective way to recover waste materials from other municipal solid waste. As a result of mapping existing waste glass containers over the district, it's emerged that most of the citizens can't take recycling services as productive or easily. For this reason it's needed to give up door-to-door system and make simulations for collecting wastes efficiently and productive. By further practices new locations should be provided to enhance the accessibility to containers by decreasing usage areas and narrowing them on site.

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