Integrated Solid Waste Management for Urban Area in Basrah District

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Abstract

The success of waste management requires accurate data on generation and composition of waste which is pivotal for the decisions towards the appropriate waste management system. A five years (2008-2012) study was conducted to evaluate the solid wastes management system in all the six divisions of Basrah district (more than 30 sub-districts). Recent investigations in 2012 resulted information that population of Basrah district has reached 1,018,000 person The quantity of municipal solid waste generated was recorded to be 634 tons per day with MSW generation rates of 0.62 kg per capita per day. Municipal solid waste density was conducted as 192.6 kg/m³ with moisture content of 31.1%. The main components of the MSW were Food wastes represents largest proportion (54.8%), followed by plastic (25.2%) and paper (7%). The study results reveal that the MSW stream has the largest proportion of biodegradable and recyclable waste. Therefore, the study recommends to use methods of waste treatment such composting, recycling and incineration in order to reduce the amount of waste that are taken to the landfill.

Keywords: Municipal Solid Waste (MSW), Management, Generation, Composition, Landfill, recycling, Compositing, Moisture Content.

الخلاصة

تحديد النظام الناجح في إدارة النفايات يتطلب بيانات دقيقة عن توليد النفايات. تم دراسة خمس سنوات (٢٠٠٨-٢٠١٢) لتقييم نظام إدارة النفايات الصلبة في كل ستة الأقسام الستة التابعة منطقة البصرة (أكثر من ٣٠ منطقة فرعية). الحسابات الأخيرة في عام ٢٠١٢ بينت أن عدد سكان منطقة البصرة وقد بلغ ١٠١٨٠٠٠ شخص وكمية النفايات البلدية الصلبة المتولدة والتي تم تسجيلها كانت ٦٣٤ طن يوميا بمعدل توليد ٠,٦٢ كيلوغرام للفرد من النفايات الصلبة في اليوم الواحد. وقد تم قياس كثافة النفايات البلدية الصلبة حيث كانت ١٩٢,٦ كغم / متر مكعب مع محتوى الرطوبة ٣١,١٪. المكونات الرئيسية للنفايات البلدية الصلبة النفايات كانت النفايات الغذائية تمثل أكبر نسبة (٥٤,٨٪)، تليها النفايات البلاستيكية (٢٥,٢٪) وثم النفايات الورقية (٧٪). نتائج الدراسة بينت أن النفايات الصلبة لديها أكبر نسبة من النفايات القابلة للتحلل وإعادة التدوير. لذلك فأن الدراسة توصي باستخدام أساليب معالجة النفايات مثل التسميد (Composting)، وإعادة تدوير (recycling) والحرق (incineration) من اجل تقليل كمية النفايات التي ترحل إلى الطمر الصحي .(landfill).

الكلمات المفتاحية: النفايات البلدية الصلبة ، أدارة ، توليد ، مركبات ، طمر صحي ، تدوير ، تسميد ، محتوى رطوبة

Introduction

Solid wastes are the materials that have become of no or less value to the real owner and therefore planned to be thrown away. The material may not necessarily be valueless, but as long as the owner throws it away, it has become a waste. Municipal solid wastes (MSW) on the other hand, are the wastes produced in urban areas. MSW, commonly known as trash or garbage in the United States and as refuse or rubbish in Britain, is a waste type consisting of everyday items that are discarded by the public (Sasikumar & Krishna, 2009).

Solid waste management encompasses all the activities from generation to the final disposal and is defined as the control, generation, storage, collection, transfer and transportation, processing and disposal of solid waste consistent with the best practices of public health, economics and finance, engineering, administration, legal and environmental considerations (Cheremisinoff, 2003).

Solid Waste Management (SWM) system in Basrah district has deteriorated recently to the point that only limited waste collection is undertaken in certain urban areas and disposal is largely to uncontrolled dump sites (Elagroudy *et al*, 2011). In 2007, the UN Habitat and UNICEF invited companies and experts to do the Integrated Solid Waste Management Master Plan for Basrah Governorate (ISWMMPBGBG) for a period of 25 years (Unicef and MMPW, 2007).

Hence for integrated solid waste planning, it is indispensable to indicate solid waste generation and its composition from the communities (Gidarakos *et al*, 2005, Gomez *et al*, 2008). Consequently, solid waste management system (SWMS) needs to be updated to suit the waste quality, quantity and composition (Manaf *et al*, 2009). In the current study, the Average Generation Rates of MSW for years 2008 to 2012 have been calculated based on real recordings. Filed investigation has been done to determine the physical composition of MSW the period from Dec 2011to Nov 2012.Then, the comparison of these results of calculations with the estimations of ISWMMPBGBG had been done to suggest some modifications or updates.

Description of Study Area

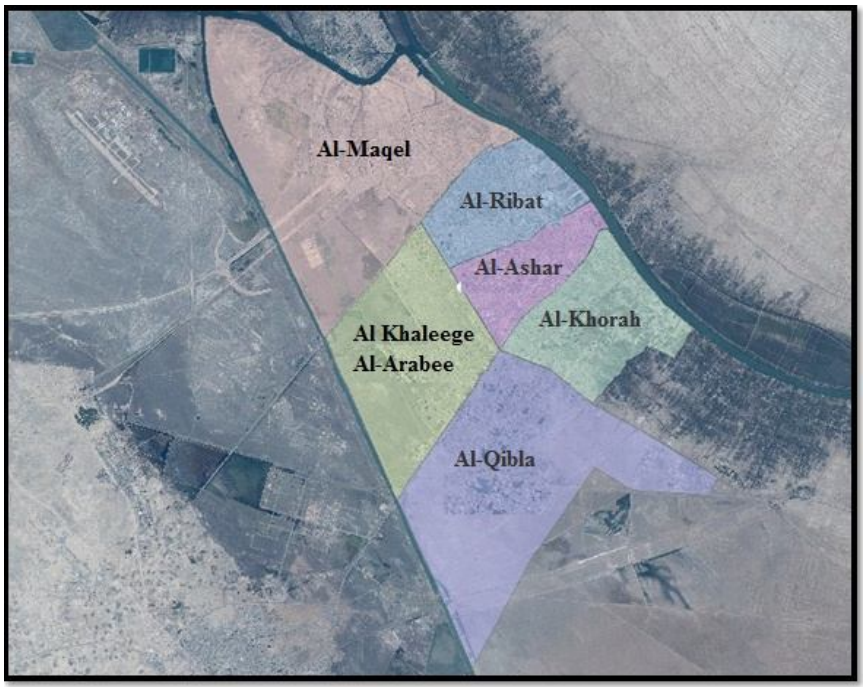
Description of study area was the first step in identifying the main factors for the management of solid wastes. for the purpose of controlling. Basra is the second Governorate in Iraq regarding volume of population and considered as the commercial capital of Iraq, its only port overlooking the Arab Gulf and its main sea outlet. Due to the vicinity of the Arab Gulf, humidity and rainfall are however relatively high. The governorate of Basrah has a hot and arid climate. The area of the Governorate of Basra amounts to (19.070) sq km. The governorate of Basrah is subdivided into seven districts: Basrah, Abu Al-Khaseeb, Al-Midaina, Al-Qurna, Al-Zubair, Fao, and Shatt Al-Arab as shown in Map (1).

Basrah district is the capital of Basrah governorate and is the most Populous urban areas in the Governorate as shown in Table (1). Basrah district is divided into six “divisions” for the purposes of solid waste collection by Municipality Directorate of Basrah district as shown in Map (2). Each division was divided into several partitions as listed in Table (2) and each partition was divided into several regions. The current study was used this classification in Basrah district to determine the population and the quantity of MSW in each division.

Map (1) Basrah Governorate Profile (MDB, 2012)

Table (1) Total Distribution of Basra Province Population for 2007 ((MDB, 2012)

District	% of Total Province Population	
	Urban	Rural
Basra District	45.5	4.4
Shatt Al-Arab District	4.00	1.4
Abu Al-Khseib	7.8	0.6
Al-Faw	0.8	0.1
Al-Qurnah	4.6	5.5
AzZubeir	11.5	5.7
Al-Madinah	4.3	3.9
Total (for Province)	78.4	21.6



Map (2): Divisions of Basrah district (MDB, 2012)

Table (2): Divisions and their partitions of Basrah district (MDB, 2012)

Division	Partitions
Al-Ribat	First Ribat, Second Ribat, Jamhoriah, Alshamshomya and Al – Muwafaqiya
Al-Maqel	Al-Ablah, Al-Hindya, first Maqel, second Maqel, third Maqel, and Hiteen
Al-Khorah	Khorah,Almotiha, Mishraq, Al-bradaiah, Sanaa, Basrah, first khorah, Muhallab and Manaawi
Al-Ashar	Khorah, kindaq, Al-Hisah, Alrsalah, Al-Asma'ai, Al-Alieah and Kifa'at
Al Khaleege Al-Arabee	First Al Khaleege, second Al Khaleege,Hay Al-Hussein, Al-shula and Al-Jihad
Al-Qibla	First Qibla, second Qibla, third Qibla, industrial of Hamdan, and Fourth Qibla

Population

Actual annual growth rate of population in Basrah district has been calculated based on the recordings of population for five years (2008 – 2012). These population recordings were obtained from the Ration Registration centers (RRCs) in Basrah district, the Iraqi Ministry of Trade (RRCs, 2012). The total annual population and

growth rate for each year of the five study years had been calculated and listed in the Table (3). Total annual population for year 2012 was 1,018,000 person.

Table (3): Population, quantity and average generation rate of MSW for the Present Study and ISWMMPBG in Basrah district for the study five years (RRCs , 2012, MDB, 2012)

Year	ISWMMPBG			Present study		
	Population (1000 capita)	Quantity of MSW (ton)	Average generation rate	Population (1000 capita)	Quantity of MSW(ton)	Average generation rate
2008	1163	1047	0.90	٩٦٧	551	0.57
2009	1187	1068	0.90	982	675	0.69
2010	1210	1089	0.90	966	875	0.91
2011	1235	1111	0.90	992	500	0.50
2012	1259	1133	0.90	1018	634	0.62
Av.	1211	1090	0.90	985	647	0.66

Average Generation Rates of MSW

The amount of MSW was affected by several factors such as standard of living, population and population growth rate which identified the quantity of MSW by determining waste generation rate per person and climate of study area (seasons, air humidity and rain), the summer seasons increases use of glass bottles and metal for cold drinks with consumption increase of summer fruits and vegetables, air humidity and rain increase the moisture content of the waste (Sharholy *et al*, 2008, Das, 2014, Rana *et al*, 2015,).

Present study has been calculated the actual MSW quantity an average generation rate for each year of the five study years (2008-2012) based on the recordings of Municipality Directorate of Basrah district. The study area was witnessed a large flocculation of annual increase rate of MSW quantity in the five years because of the instability in the economic situation affecting on the people income and the financial budget allocated to the municipality and the security situation affecting on the possibility of waste collection and give opportunities for private companies to operate within the region.

This study indicated that the total quantity of MSW generated in 2012 was 634 ton, while the estimation of ISWMMPBG was 1133 ton as shown in Table (3). Furthermore, this study indicated that the average generation rate of MSW in 2012 was 0.62 kg/capita/day, while ISWMMPBG was considered value as 0.90 kg/capita/day as shown in Table (3). It seems to be the actual quantity of MSW lower than the expectations of ISWMMPBG. The low per capita waste generation of some low income families may be due to the increase in household sorting of paper, bread and bottles at the point of generation since they are easily sellable (Sulaymon A.H. and Ibraheem J.A., 2010). This value of waste generation (0.62 kg/capita/day) has been make the Basrah district within the low income countries which have the lowest waste generation rates, ranging between 0.4 to 0.9 kg per capita per day (World Bank, 1999).

Density of MSW

For most purposes relating to the collection of wastes, it is necessary to know the volume of the wastes rather than their weight. Perhaps even more important is the density, which enables the conversion of weights into volumes and vice versa. It must be recognized that waste density varies considerably during handling, having different values in the initial storage container, in the truck body after loading, and again in the

truck body after transfer or after the wastes have unloading during the journey to the disposal site (UN-HABITAT, 2010).

The density of MSW was measured by using cylindrical container with height of 0.95m and diameter of 0.6m. The container was filled by MSW without compressing the contents.

$$DS = W/Vo \quad \ldots (1)$$

DS: Density of MSW (kg /m^3)
W: weight of MSW sample
Vc: Volume of container= 0.268m^3

From the measurement of present study, the density of MSW was 192.6 kg/m^3, while 267 kg/m^3 from ISWMMPBG. Wastes of high density as in ISWMMPBG, reflects a high proportion of food wastes and moisture content. Low-density wastes, on the other hand as in present study, indicate a high proportion of paper, plastic and other combustibles.

Moisture Content

Moisture content have an essential role in determining appropriate MSW disposal or treatment method (landfilling, incineration, composting, etc.). The moisture of solid wastes is commonly expressed as percentage of wet weight of the material. For the most MSW the moisture content varies from 15% to 40%, depending on humidty and weather conditions, waste composition, and the season of the year (Tchobanoglous *et al*, 1993; Sharma and Lewis, 1994).

Moisture content is closely linked with food waste, quantity of rain and atmospheric moisture. It was taken(3kg) as a sample of food wastes from(650kg) of MSW, drying the sample at a temperature of 105°c for 24 hours[43] and weight it.

$$M = \frac{Wwet - Wdry}{Wwet} * 100 \quad \ldots. (2)$$

- M = Moisture content of sample
- W_{wet}= Weight of wet sample
- W_{dry}= Weight of dry sample

It was determined the total weight of water in MSW, and then determined the percentage weight of water in MSW:

$$W_w = M^* W_{food} \quad \ldots. (3)$$

$$W_w \% = W_w / W_s \quad \ldots. (4)$$

- W_w = total weight of water in MSW
- $W_{food=}$ total weight of food wastes in MSW
- W_w % = percentage of total weight of water in MSW
- W_s = weight of MSW

The measurements of the present study have been indicated that the average moisture content of MSW in Basrah district was about 31.1%. Figure (1) shows the variation of MSW moisture content during the study period. Increase generation rate of MSW lead to increase rate of moisture content because of excessive consumption of foods such as fruits and vegetables during the hot weather (summer season).

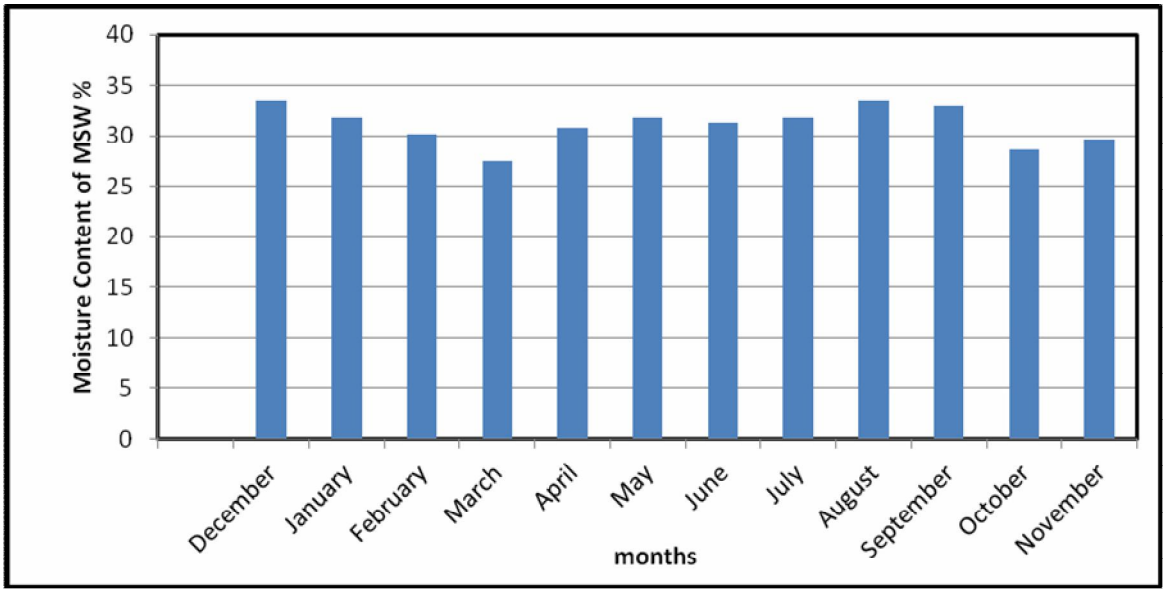


Figure (1) Variation of MSW moisture content during the study period

MSW composition

Success of any municipal solid waste management system relies on precise data about the quantity and types of material being generated as waste. Waste composition studies are essential to any proper waste management strategy for a variety of reasons, including a need to estimate potential materials recovery, to identify sources of component generation, to facilitate design of processing equipment, to estimate physical, chemical, and thermal properties of the wastes, and to maintain compliance with regulations (Gidarakos *et al*, 2005; Kreith, 1994).

The composition of waste generated is extremely variable as a consequence of seasonal variations, lifestyle of the population, demographic structure, and geographic condition and legislation factors which increase or decrease its volume. This variability makes defining and measuring the composition of waste more difficult and at the same time more essential for long-term urban development planning. (.Sfeir *et al*, 1999; Abdalla 2011; AbdAlqader and Hamad 2012; Nyankson *et al*, 2015)

The determination of the mean composition of MSW was based on manual sorting of a number of waste samples over a selected time period covering half-month for each month. Every sample of MSW was collected in container of volume 3.375 m^3 (3m*1.5m*0.75m). The weight ratio of each component in the sorting sample was calculated by the weights of the components. The mean waste physical composition was calculated using the results of each sorting samples.

Table (4) and Figure (2) show the average components of MSW in study area for the period (Dec 2011-Nov 2012). Food wastes represents the largest proportion (54.8%), followed by plastic material (25.2%), paper (7%), textile (3.5%), metal (3.04%), glass (2.92%), wood (2.6%), leather products(0.54%) and others (0.4%). These results were taken as a baseline for the study area.

The comparison of MSW compositions from prediction of the Integrated Solid Waste Management Master Plan (ISWMMPBG) of Basrah governorate and the present study in Basrah district are shown in Table (5). After food waste, plastic and paper waste is the second major constitute at MSW. The quantities of plastic in the previous study (ISWMP) is 7.10%, while in the current study 25.20%. The paper amounts in the previous study (ISWMP) is 3.80%, while in the present study was 7.00%. Basrah district have started producing more plastic and paper waste due to increased use of plastic packaging, plastic shopping bags, water bottles, news paper,

cardboard boxes, Paper egg cartons and other goods/appliances using plastic or paper as the major component. Plastic and paper waste recycling can provide an opportunity to collect and dispose of plastic and paper waste in the most environmental friendly way and it can be converted into a resource.

Table (4): Components of MSW in Basrah district (Dec 2011-Nov 2012)

Composition %	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Average
Food wastes	54.67	51.33	52.22	51.61	53.29	52.86	56.56	59.32	58.49	56.21	56.18	54.89	54.8
Plastic	28.46	27.92	25.63	25.8	22.95	24.23	25.62	23.92	21.85	24.94	25.86	25.2	25.2
Paper	8.13	7.99	9.23	6.11	5.78	3.59	9.13	10.25	4.29	5.67	7.05	6.73	7
Textile	3.84	5.42	4.63	2.77	3.89	0.72	1.65	3.84	1.63	4.41	4.31	4.9	3.5
Metal	4.23	2.4	1.02	1.02	3.16	3.05	4.02	4.13	4.61	3.63	2.24	3.01	3.04
Glass	1.39	0.27	1.15	2.16	3.12	2.35	4.12	4.03	6.14	5.01	2.14	3.13	2.92
wood	1.61	0.42	1.53	1.8	2.66	3.44	3.71	2.74	1.81	3.67	4.72	3.09	2.6
Leather Products	0.42	0.13	2.31	0.11	0.1	0.22	0.25	2.1	0.15	0.02	0.1	0.62	0.54
others	0.52	0.61	0.83	0.62	0.3	0.55	0.11	0.21	0.16	0.19	0.35	0.36	0.4

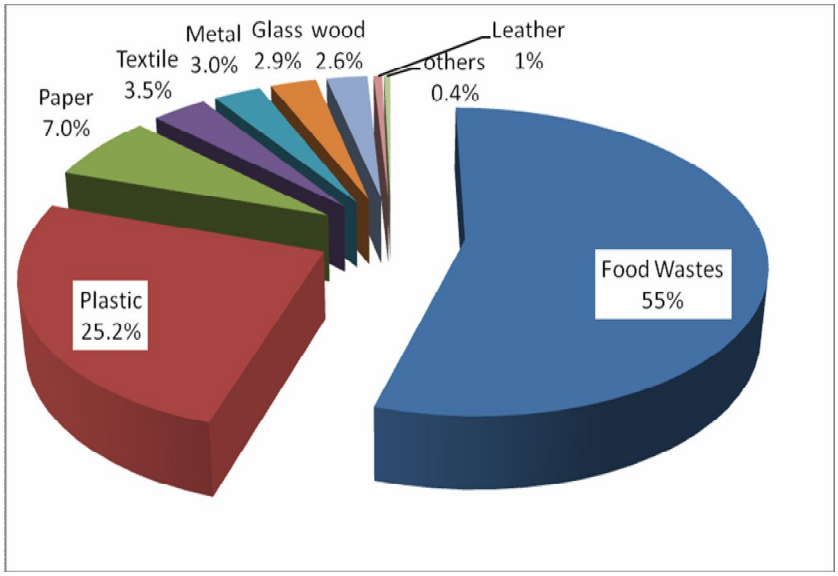


Fig.(2): MSW Components during the study period

Table (5): Composition of MSW of ISWMMPBG and Present study in Basrah district

Composition%	ISWMMPBG	Present study
Food Wastes	66.6	54.8
Plastic	7.1	25.2
Paper	3.8	7
Textile	2.7	3.5
Metal	3.5	3.04
Glass	5.2	2.92
Wood	1.8	2.6
Leather Products	-----	0.54
Others	------	0.4

MSW is usually mixture of various waste components, Table (6) shows the ratio of MSW components which could be disposed of by some methods before final disposal such as recycling of plastic, metal, paper, glass and textile which was represented by 41.7%, composting of food wastes which was represented by 54.8% and incinerating of wood, paper, textile, and leather products which was represented by 13.7%.

Table (6): Components of MSW in Basrah district which can be recycled, composting or incinerating for the study period

%weight of components which can be disposed of		Components	Methods of disposal
Present study	ISWMMPBG		
54.8	66.6	Food wastes	Composting
41.7	22.3	Plastic, metal, paper, glass and textile	Recycle
13.7	8.3	Wood, paper, textile, and leather products	Incineration

The reason of decreasing the proportion of composting materials ratio in present study (54.8%) was a decline in the proportion of food wastes, increase ratio of wastes recyclable because of the high proportion of plastic as well as for the incineration because of the high rate of paper.

Table (7) shows if previous operations were used in certain proportions, it would reduce the amount of waste and thus increase age of cell fill in the landfill. If composting process was making as a (100%), then the quantity of MSW was reducing from 634,400 kg/day to 286,748.80 kg/day.

Table (7): Quantity of MSW disposal processes opportunity in Basrah district for the study period

Process	Quantity of MSW (kg/day)
Composting 100%	286748.80
Recycle 100%	370108.96
Incineration 100%	547867.84

Conclusions

Based on the results and within the limitations of this study the following conclusions can be drawn for Basrah district :

- For the study years (2008-2012), the average population size was 985,000 person and average daily solid waste generated is about 647 tons/day or 236155 ton per year. The average generation rate of MSW was (0.66) kg/capita/day. This value of waste generation has been make the Basrah district within the low income countries.
- The actual quantity of MSW generated (current study) was less than the estimated by the ISWMMPBG.
- For the study period (Dec. 2011 to Nov. 2012), MSW consists of food wastes which represents largest proportion of (54.8%), followed by plastic material (25.2%), paper (7%), textile (3.5%), metal (3.04%), glass (2.92%), wood (2.6%), leather products (0.54%) and others of (0.4%).
- The actual quantity of paper, plastic, textile, and wood from the current study were more than that expected by the ISWMMPBG. While, The actual quantity of Food

Wastes, Metal and Glass from the current study were less than that expected by the ISWMMPBG.

- The study results reveal that the MSW stream has the largest proportion of biodegradable (Food wastes) and recyclable waste (plastic , paper and glass). If waste management options such as composting, recycling and energy recovery are to be practiced in the future, there is a greater possibility of reducing.
- MSW has a low density (192.6 kg/m^3) which indicate a high proportion of paper, plastic and other combustibles in MSW.
- MSW has a moisture content (31.1%) that reflects a high proportion of food wastes in MSW.

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