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Municipal Solid Waste Quantity, Ingredients, and Site Disposal Problems in Pshdar District in Sulaimanyah: Iraqi Kurdistan Region, Iraq.

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ABSTRACT

Over the past years, the high generation of municipal solid waste has been identified as a considerable global environmental issue, due to population growth, economic development, and the industrial revolution. The present research study was conducted to evaluate the quantity, ingredients, and generation of municipal solid waste (MSW) in Pshdar district during winter and summer in 2019. The results revealed that the average of solid waste production in the district reached 94 tons/day and 0.761kg-capita/day. The most abundant MSW constituents are organic matter forming 75.71% of MSW of the district, followed by 13.18% of plastic content and the least ingredient is metal 0.93%. While the average ratio of paper and cardboard, textile and leather, and glass waste ingredients are 3.74%, 4.85%, and 1.66% respectively. The seasonal effect on solid waste content has been observed obviously in this research, more specifically in organic matter and textile & leather, as well as in waste generation rate. Organic matter increased from 70.73% to 80.68% from winter to summer, while, percentage of textile and leather significantly declined from 6.93% to 2.76% from winter to summer. Similarly, waste generation rate was reduced from wet to dry season from 0.846kg-cap/day to 0.676kg-cap/day.

KEYWORDS

Municipal solid waste, waste generation, Pshdar district, landfill site.

1. INTRODUCTION

1.1. Solid waste management background

The solid Waste is one of the issues that has risen human fear since the beginning of the history, where the human was always thinking about the appropriate way to discarded of his waste, particularly, when it initiated to gather in his surrounding living area. Therefore, human started to think about innovative methods to solve this problem that has threatened this planet. Thus, the solid waste has been discarded away from residential area.

The solid waste management issues have been started with preliminary modern human life on the earth planet. However, it has become one of the most considerable global problems as a result of population growth, economic development and industrial revolution. Inadequate management of solid wastes influenced the biotic environment as well as public health, sometimes causing serious health problems. Today's world for sustainable development purpose requires accurate solution to different solid waste issues (Ministry of Environment, 2014). The global projected waste generation is expected to upsurge to 2.59 billion tons of waste annually, and by 2050, waste generation through the world is anticipated to reach 3.4 billion tons (Silpa Kaza, et al., 2018).

In Iraq, and its Kurdistan region solid waste, especially Municipal Solid Waste [MSW], is a serious issue in urban areas. In Iraq, a huge quantity of waste was generated after year 2003 as a result of population expansion, human consumption and with unlimited economic openness, which led to a complicated issue regarding environmental pollution. In addition, other problems are lack of vision and mechanisms to cope with the massive quantities of waste and incapability of the private sector to contribute in resolving this problem as it fits (Jassim M. M. 2018).

Particularly this study focused on Pshdar district located east of Sulaimanyah province. The solid waste problem is aggravated due to the absence of proper solid waste management systems and nonscientific disposal method in the district. Solid Waste is a common ordinary household and commercial waste, called refuse or municipal solid waste (MSW) which includes any unwanted solid and semisolid materials discarded by a community with different contents such as garbage, which is food waste, and rubbish, almost everything else in your garbage can. Trash is larger house items, such as old refrigerator. Until fairly recently, refuse was mostly food wastes, but new materials such as plastics and aluminum cans have been added to refuse (Jassim M. M. 2018) and (Ati U. Z. 2011) . An essential environmental concern of urbanization is the quantity of solid waste that is produced at a rate that exceeds

the capability of municipal authorities to manage it, initiating considerable impacts on the environment, human health, and the quality of life. Some other difficulties are further complicated by the lack of budget as well human resources trained in solid waste management practices in the different steps such as collection, transportation, handling and final discarding. While alternatives such as recycle reuse and recovery of the solid waste are obviously demand and supply driven or disorganized in most cases (Ruth F. et al, 2003) and (Jassim M. M. 2018).

Over the last decades, the world has faced a substantial increase in volume of waste disposal into the environment. The high generation of municipal solid waste has been identified as main world environmental issues, and creates environmental consequences such as ground water and surface water contamination due to leachates; soil contamination by direct solid waste contact or leachate and air pollution when it is burnt which ultimately become a source of spreading diseases by vectors such as insects, birds and rodents (Mohammad T. M., 2011). The organic waste which is a great part of MSW, if improperly managed or left without any treatment can result in substantial degradation of water, soil and air quality (Romeela M. 2007). These untreated organic wastes serving as a reservoir of pathogens, applicable habitat for pests such as flies breed, rats and mosquitoes, become a vector to transmit the serious diseases (Ahmed A. B., 2011).

Solid Waste is difficult to identify, define, and categorize because it is naturally a heterogeneous- material, relating to substances, materials, and products. (Pal T. W., 2005). For example, contents found, at the collected samples from district solid waste, included: a massive amount of organic matter such as food, vegetable and fruit peelings/remains, street-sweepings, plastics, papers and plastic bags, packaging materials, used/broken plastics and glass, rubber, old/turn clothes, pieces of broken furniture, and metals. These varieties of sources generation of municipal solid waste make impossibility of waste management program particularly in waste separation phase and thus it is difficult to overcome.

Dependable waste management data and scientific research provide a wide-ranging resource for a comprehensive, critical and informative assessment of waste management alternatives in all waste organization programs for any community and authority. Research has shown that these required essential statistics are difficult to obtain in many developing and undeveloped countries (Kodwo M. K, et al, 2015). Even if they are accessible, they are inconsistent because the urban wastes produced from many sources cannot be validated because it mostly depended on assumption rather than scientific measurements (Diana S., 2018). The lack of

dependable data in developed countries and absence in underdeveloped countries are often a main source of confusion and hesitation in the minds of investors who has plan to do investment in solid waste management sectors (R. Courth, C., 2011).

Similarly, Iraq as one of the Middle East countries has faced a serious problem of solid waste management. Most municipalities in Iraq lack operative means of solid waste collection and treatment which has littered the streets of Iraq with garbage. While municipal solid waste collection system is available in some cities, user participation is very low. The solid waste disposal process is operated in landfill sites with outdated methods such as open dumping methods instead of using modern methods which is operating and designing of sanitary landfill. The absence of developed recycling programs and the lack of operational control and treatment of solid waste are major sources of public health hazard environmental pollution (UNAMI Newsletter, 2011). The negative impacts of poor solid waste management programs may potentially be dangerous for those who live in third world countries, which currently constitute 80% of world's population. It is obvious that inadequate solid waste management system causes land, water and air pollution and is frequently result of a lack of economic resources (Ali Ch., et al., 2015).

There are four fundamental methods for discarding MSW: 1-Recovery or recycling of some materials: As glass, metal, paper, and plastic; 2-Recovery of energy: by incineration of organic waste constituents; 3-Bioconversion: the natural organic constituents of MSW can be oxidized aerobically under organized situation. 4-Landfilling: the unrecyclable materials have to be discarded in appropriately designed sanitary landfills (Ministry for environment, Manatn, 2009).

1.2. Pshdar District Background and Present status of solid waste management

Pshdar district is focused as the studying area for this research. It is one of the districts of the province of Sulaymaniyah in Kurdistan Region of Iraq; it is located about 153 Km East of the Sulaimanyah City, directly on the Iraq-Iran border (Karen Radner et al., 2017). The most settled urban center is Qaladize Town, with has five Sub-Districts such as Sangasar, Zharawa, Halsho, Hero and Isawa. Whole district covers a surface area about 1456 km^2; with population of 123179 (Map of estimated population of Sulaimanyah governorate, 2015). As a result of no separate solid waste system in the district and no sanitary landfill, the collected MSW in the area was dumped in an open area as displayed in Figure 1, up to June, 2019 where there is not appropriate location for dumping MSW since site selection for landfill needs some essential scientific and environmental criteria such as Topography, wind

direction, distance from residential area, distance from surface water, distance from protected area, geological properties, land use, ground water level, distance from main roads, slope of the area, agriculture area, distance from airports, and hydrology. (Sehnaz S., et al., 2010). According to standard requirements and criteria mentioned for landfill site selection, the allocated dumping site is not appropriate and is scientifically not acceptable because of its topography (see Figure 1), proximity to seasonal water stream, proximity to both the residential area (see Figure 2, about 1064m to the district boundary - and less than 1500m to main river - Little Zab River, that provides drinking water for Qaladize town.

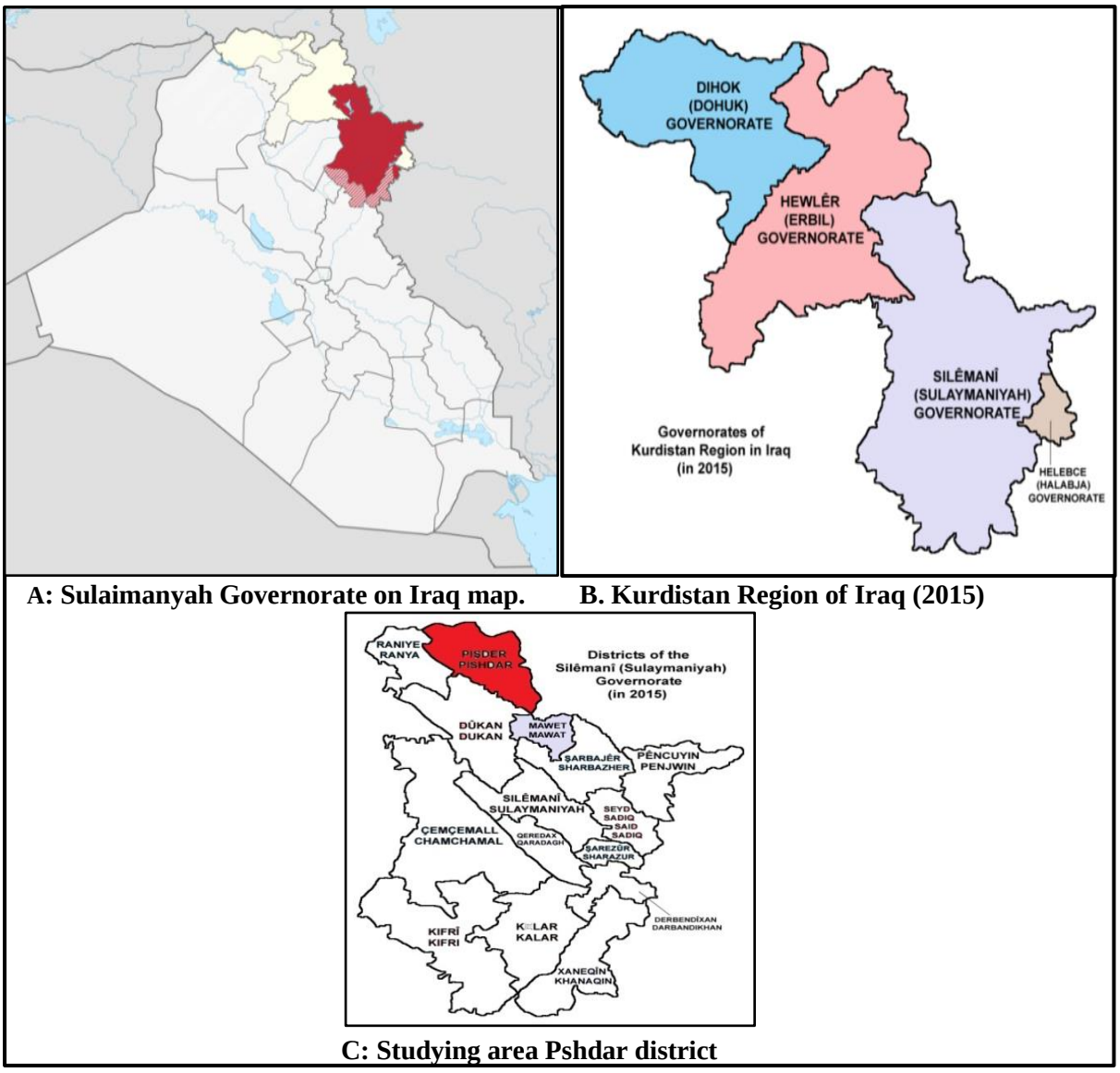
Since 2014 the district municipality has had responsibility of monitoring the activities of Garex Company as contracted company for solid waste management in the Pshdar district, they used different methods of collection such as curbside pickup and community bin pick up. In addition, they are responsible to discard whole district's wastes in the disposal site without any treatment and other alternatives such as recycling, reuse, composting and incineration.

Fig. 1. Pshdar waste disposal site.) Photo author

Many studies have been done in Iraq regarding to the solid waste management. United Nation Environment Program UNEP has also supported many studies concerning quantity and

composition of MSW and environmental assessment (UNEP in Iraq, 2007). Another research has been done about characteristics and composition of Solid waste of Mosul city (Sati M., et al., 2013). In the southern Governorates of Iraq a survey has been conducted about waste management (Ryiadh A. et al., 2012). A comprehensive study has been done in Kerbala concerning waste management process during religious events and demonstrated the solid waste composition (Muhammad A. et al., 2017). While in Kurdistan Region of Iraq some other studies have been conducted regarding to solid waste management particularly in Erbil. For example (Shoukr et al., 2019) conducted a study about recyclable solid waste materials management. (Sirwa Q. S., 2017) conducted a research about the environmental influence valuation of Erbil dump site area and found negative impact on the around area is a study. The available research in Sulaimanyah governorate about solid waste management is a case study in Chamchamal (Dwbra valley open dump) (Chrakhan R., et al., 2018). The present study is the first research study about solid waste management in Pshdar district which is a part of Sulaimanyah province. The main purpose of this study was to assess the composition and quantity of MSW and point out to separate the recyclable waste materials to reduce the amount of waste disposal particularly in open dumping site which lead to different environmental hazardous and health problems.

Fig. 2. Pshdar open dumping site, a proximity to seasonal stream, the little Zab River and the residential area.



A: Sulaimanyah Governorate on Iraq map. **B. Kurdistan Region of Iraq (2015)**

C: Studying area Pshdar district

Fig. 3. The location of studying area.

2. METHODOLOGY

2.1. Materials and Methods

The current research study was conducted during two seasons in 2019, winter and summer, since the household solid waste generation and its contents maybe different due to seasonal variation and socioeconomic status. In both periods different samples were collected in the morning at six different zones of the district namely Zone 1 which represents Qaladize town as a center of the district, Zone 2, Zone 3, Zone 4, Zone 5 and Zone 6 which represent the Sangasar, Zharawa, Halsho, Esewa and Hero sub-districts respectively. Waste of each zone was individually collected using compactor truck and dumper truck designed to exclusively transmit the waste to dumping station. Each truck was arbitrarily nominated from each zone and weighed. The waste samples for each zone were mixed and final sample was subdivided

into four equal quarters. The components were separated manually and weighed utilizing a digital balance and the percentage of each component was calculated (see Figure 4).

Fig. 4. Waste separation process, winter season.

2.2. Percentage Ratio calculations of solid waste components

Percentage ratio of each component was calculated for all different zones as below:

The total quantity of each component was calculated from all zones, and then the total weight of municipal solid waste in the district was found

The total quantity of solid waste in the district for winter season was calculated per day which is = 104.229 Tons/day.

Organic matter % = $\frac{[\,\boldsymbol{weight\ zone\ 1+zone\ 2+\cdots\ldots+zone\ 6}\,]}{\boldsymbol{total\ quantity\ of\ MSW\ of\ the\ district}} \times 100 = \frac{73.726}{104.229} \times 100 = 70.73\%$

Paper & Cardboard% = $\frac{4.398}{104.229} \times 100 = 4.22\%$

Plastic % = $\frac{15.056}{104.229} \times 100 = 14.45\%$

Metal% = $\frac{1.328}{104.229} \times 100 = 1.27\ \%$

For calculating the Generation Rate of solid waste (GRW) in the district depending on the obtained date, the below equation was used:

$$GRW = \frac{Qs}{P} \quad \ldots\ldots\ldots \quad (1)$$ (Ali Chabuk, et al., 2015)

Where:

GRW: Generation of solid waste kg / (capita –day).

Qs: total Quantity of solid waste (kg)

P: Population of the studying area

For determining the generation rate of solid waste in the district the above equation was applied depending on the population which is about (123179 inhabitants).

According to winter season data:

$$GRW = \frac{104.229 \times 1000}{123179} = 0.846 \text{ kg/capita-day}$$

According summer season data:

$$GRW = \frac{83.313 \times 1000}{123179} = 0.676 \text{ kg/capita-day}$$

3. RESULTS AND DISCUSSION

It has been found that the quantity and ingredients of municipal solid waste vary from place to place. These distinctions are as a result of production facilities, different consumer style, population compositions, per capita waste production, and cultural, social and economic status, which is strongly influenced by economic factors. The variations in MSW composition may intensely impact the quality of the waste, which affects discharges from landfills, the quality of ignition deposits and other considerations of waste management systems (Shafiul A., et al., 2004). Therefore this research study mainly focused on determining the MSW compositions; and in order to get more precise data about how the quantity and ingridents on MSW are influenced by seasonal variations (as shown in the study by (Gintaras D., et al., 2014), this study conducted in two different seasons: winter and summer.

In order to calculate the waste generation rate, all MSW samples were collected from different zones, weighed during the analysis period and an average of all wastes generated in both seasons were evaluated as 104.22 tons and 83.31 tones for winter and summer respectively. The average solid waste components and quantity data for all zones in winter and summer season are demonstrated in the Table 1 and Table 2.

Table 1. Total quantity and ingredients of solid wastes data for winter season, 2019.

Zones	Total solid waste day (ton)	Main Components of the solid wastes					
		Organic matter ton/day	Paper& Cardboard ton / day	Plastic ton/ day	Metal ton /day	Glass ton /day	textile & leather
Zone 1	65.580	51.494	2.728	7.654	0.256	0.302	3.146
Zone 2	19.909	11.802	0.671	4.128	0.676	0.474	2.158
Zone 3	10.685	5.933	0.304	1.637	0.231	1.538	1.042
Zone 4	3.185	1.861	0.225	0.634	0.124	0.112	0.229
Zone 5	3.270	1.863	0.283	0.594	0.032	0.048	0.450
Zone 6	1.600	0.773	0.187	0.409	0.009	0.029	0.193
Total Quantity	104.229	73.726	4.398	15.056	1.328	2.503	7.218
Percentage	100 %	70.73%	4.22%	14.45%	1.27%	2.40%	6.93%

Table 2. Total quantity and ingredients of solid wastes data for Sumer season, 2019.

Zones	Total solid waste / day (ton)	Main Components of the solid wastes					
		Organic matter ton/day	Paper &Cardboard ton / day	Plastic ton/ day	Metal ton /day	Glass ton /day	textile & leather
Zone 1	52.792	44.720	1.325	5.300	0.098	0.197	1.152
Zone 2	11.737	8.077	0.505	2.145	0.252	0.281	0.477
Zone 3	9.503	6.774	0.404	1.618	0.097	0.206	0.404
Zone 4	6.972	6.119	0.191	0.514	0.023	0.039	0.086
Zone 5	1.03	0.917	0.51	0.025	0.007	0.012	0.018
Zone 6	1.279	0.613	0.152	0.320	0.006	0.028	0.160
Total quantity	83.313	67.22	2.628	9.922	0.483	0.763	2.297
Percentage	100 %	80.68%	3.15%	11.91%	0.58%	0.92%	2.76%

Municipal solid waste Composition: There are six main components of MSW assessed in this survey specifically organic matter, paper and cardboard, plastic, metal, glass and textile & leather. According to Table 3 and Figure 5 in this research study, organic matter is the most abundant ingredient of the waste in both periods with the average 75.71% consisting of decayed and biodegradable materials, followed by plastic waste ingredients with the amount of about 13.18% forming recyclable material. On the other hand, the least waste ingredient is

metal which is about 0.93%. While the average ratio of paper and cardboard, textile and leather and glass waste constituents are 3.74%, 4.85% and 1.66% respectively. Similar results were attained in Erbil, Baghdad and Iran related studies; for instance in Mahabad town organic matter reached to 75%, paper 3.79%, plastic 9.78%, metal 1.19% and textile 1.9% (Tasnim F. Ch., 2016), (Yahya A., 2011) and (Soran E., et al., 2015). Organic waste which is the largest portion of MSW in this study represents the largest amount of potentially recyclable and forms the highest part of domestic waste. This shows that; there is the opportunity of producing compost programmed for local nurseries. Compost is biological degradation or breakdown of organic substance under aerobic conditions. Through the microbial activity proceeding during composting process, organic matter is disintegrated into a stable, humus-like substance (Hussein I. et al., 2018). Pshdar's MSW is appropriate for composting process as a result of its high organic waste contents. Since there is no composting plant in the area, it is very important to the public or privet sector in the district think about establishing a composting plant.

Municipal Solid Waste generation: The total district waste generation and physical analysis of waste and comparison of waste constituents with other local and international researches are shown in Table 3 and Table 4, respectively. As demonstrated in Table 3, the waste generation rate in this research was (0.846kg/capita/day) for winter, (0.676kg/capita/day) for summer season and average waste generation is (0.761kg/capita/day) which is lower than the average waste generation rate reported for Europe and central Asia (1.18kg/cap-day). And it is higher than some Iraqi cities such as Mosul (0.680) and Babylon (0.670). On the other hand, the calculated generation rate is lower than Baghdad and Erbil cities which are about (0.900 and 1.27 kg/cap-day) respectively.

Seasonal variation impact on MSW generation and ingredients percentage: According to Table 5 and Figure 5, the most substantial difference in MSW contents between the winter and summer periods can be observed in organic matter and followed by textile and leather. The average quantity of organic matter in winter was 70.73% while it grew up to 80.68% in summer period. The reason for this variation is supposed to associate with food and other organic matter damaging due to high temperature during summer period which rises up to 45–47 °C and high consumption of agricultural production since the district is one of the best places for agricultural sector. However, the rate of solid waste generation declined from wet season to dry season from 0.846kg/cap-day to 0.676kg/cap-day. Another significant difference was seen in textile and leather waste.

Table 3. Average waste ingredients quantity and weight percentage of MSW in Pshdar District for winter and summer season in 2019.

Ingredients	Winter (%)	Ton/Day	Summer (%)	Ton/Day	Average	Ton/Day
Organic waste	70.73	73.73	80.68	67.22	75.705	70.476
Paper $ Cardboard	4.22	4.40	3.25	2.628	3.735	3.514
Plastic	14.45	15.05	11.91	9.922	13.18	12.486
Metal	1.27	1.33	0.58	0.483	0.925	0.906
Glass	2.4	2.503	0.92	0.763	1.66	1.633
Textile & leather	6.93	7.22	2.76	2.297	4.845	4.758
Total	100	104.23	100	83.313	100	93.77
Generation rate (kg/capita-day)	0.846		0.676		0.761	

Table 4. Comparison of solid waste generation rates of the current research with the other reported researches.

References	Generation rate (kg/cap-day)	Organic waste%	Paper $ Cardboard %	Plastic %	Metal%	Glass %	Textile & Leather %
Current Study	0.761	75.71	3.74	13.18	0.93	1.66	4.76
Baghdad, Iraq (Tasnim F.CH., 2016)	0.900	70.00	5.00	5.30	2.20	2.20	-
Erbil, Iraq (Shoukr Q. et al. 2019)	1.27	28.00	13.00	35.00	2.00	2.00	5.00
Mosul, Iraq, (Sati M.&Taha A. ,2013)	0.680	68.17	9.6	5.29	3.15	2.61	5.48
Babylon, Iraq (Ali Chabuk, et al., 2015)	0.670	55	5	8	10	5	5
Tehran, Iran (Soran Erami, et al., 2015)	0.840	69.66	9.37	6.82	1.53	-	1.89
Mahabad, Iran (Soran Erami, et al., 2015)	0.878	75.17	3.79	9.78	0.83	-	1.93
Istanbul, Turkey, (Huseyin K. O., et al., 2016)	0.955	61.64	5.72	8.75	0.82	4.60	-
Ghana, (Kodwo M. K., et al., 2015)	0.531	61.00	5.00	14.00	3.00	3.00	2.00
Europe and Central Asia, (Silpa Kaza, et al.,2018)	1.18	36.00	18.60	11.50	3.00	8.00	-
Al-Najaf, Iraq (Ryidh A. Y. & Zaidun N.A., 2009)	0.42	69.03	3.06	5.09	7.09	2.71	3.59
Nasiriya, Iraq (Ryidh A. Y. & Zaidun N.A., 2009)	0.68	70.18	3.42	6.75	3.55	3.95	2.54

The textile and leather waste proportion was determined to be 6.93% during winter season and it decreased considerably more than 2 times to 2.76% in summer period. The reason behind this variation is obviously associated to use more clothes and leather during winter season, since the Pshdar district has cold winter and hot summer and the temperature degree substantially changes from 47°C to -5°C from summer to winter periods. A slide variation occurred in the percentage of paper and plastic between both periods, paper declined from 4.22% to 3.15%, similarly, Plastic percentage reduced from 14.45% to 11.91% from winter to summer. Meanwhile the significant drop has been observed in the percentage of glass and metal due to seasonal variation, the glass percentage dropped from 2.4% to 0.92%,and metal percentage from 1.27% to 0.58% from winter to summer.

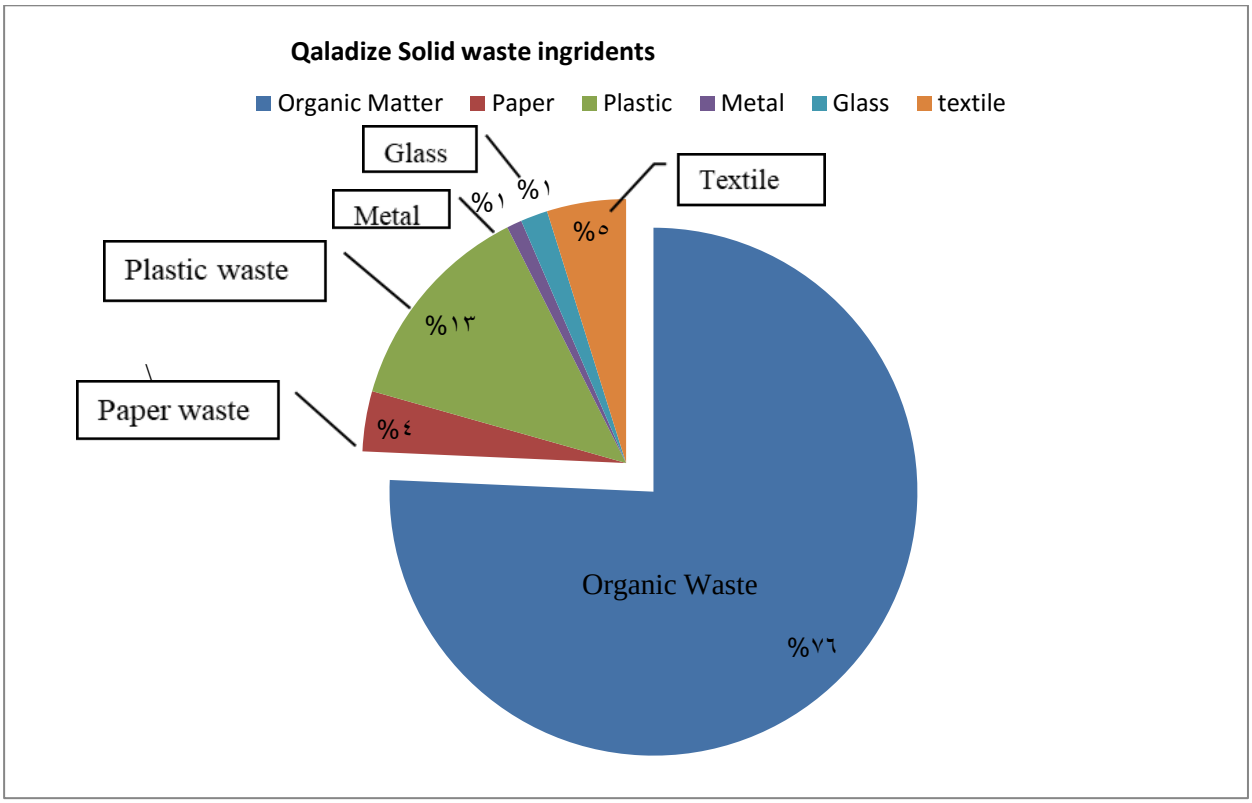


Fig. 5. Average of Total District Solid waste ingredients, 2019.

Table 5. Percentage Average of MSW contents and seasonal percentages.

Solid waste Components	MSW Percentage %			
Seasonal Effect	Winter	Summer	change%	Average
Organic Matter	70.73	80.68	9.95	75.71
Paper	4.22	3.15	-1.07	3.68
Plastic	14.45	11.91	-2.54	13.18
Metal	1.27	0.58	-0.69	0.93
Glass	2.40	0.92	-1.48	1.66
Textile & leather	6.93	2.76	-4.17	4.84
Generation rate (kg/capita-day)	0.846	0.675	-0.171	0.761

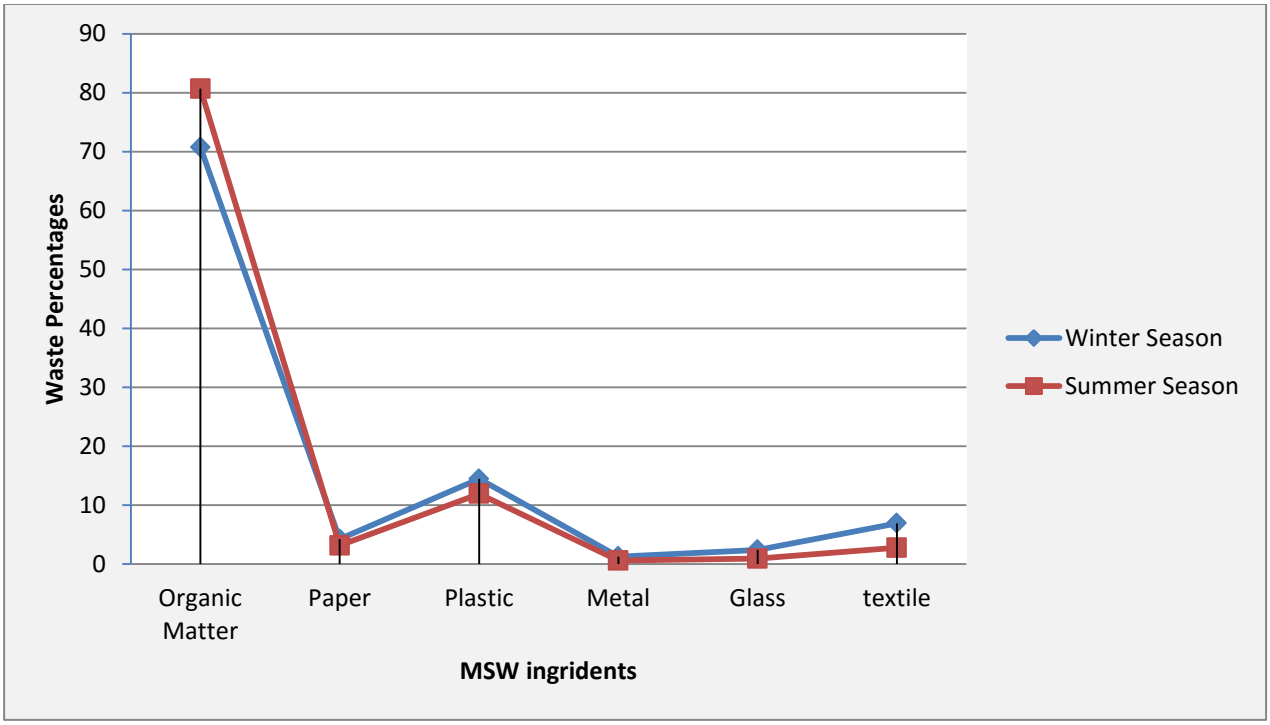


Fig. 5. Seasonal variation impacts on MSW contents.

4. CONCLUSIONS

Over the last years, Solid waste management which includes reducing, recycling and disposal of waste has become increasingly imperative because a waste generation has been increasing due to a growth in population and financial development. This research focused on Municipal Solid waste of Pshdar district in Kurdistan Region of Iraq, the solid waste generation, solid waste ingredients, disposal and seasonal impacts on solid waste contents have been assessed in this research study. It is found in the research that total average of waste generation in the

district was 0.761kg/capita-day and it is fewer than average of waste generation of Europe and Central Asia which is (1.2kg/cap-day), as well as smaller than Baghdad (0.900kg-cap./day) and Erbil (1.27kg-cap./day) cities. However, it is greater than Mosul, Babylon and Ghana waste generation which are (0.680, 0.670 and 0.531kg/cap-day) respectively. The study revealed that the Organic waste is the most abundant content of district MSW in both winter and summer which is 70.73% and 80.68% respectively. Furthermore, solid waste disposal method in the district has been evaluated and showed that open dumping method is not scientific and ecofriendly method which is used in the area. Finally, the authority with cooperation with private sector should have an adequate plan to improve solid waste management process and provides some alternatives to reduce the quantity of waste that goes to landfill. Moreover, both private and public sectors should also raise the public awareness toward the waste management process by holding up workshops and panels; which is thought to encourage public participation in solid waste management.

5. ACKNOWLEDGEMENTS

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