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THE CORRELATION BETWEEN HOUSEHOLD WASTE COMPOSITION AND ANNUAL INCOME – COMPARATIVE ANALYSIS BETWEEN MAJOR UKRAINIAN CITIES AND SHARJAH, UAE

ABSTRACT
This article is devoted to exploring the correlation between household waste composition and the annual income per resident in the cities in Ukraine and UAE. The available household waste morphology analyses in major Ukrainian cities and in Sharjah city are compiled and unified then, correlated with the residents annual income. Both financial and cultural factors were found to have influence on the content of several components of the household waste, while food waste content was found to be purely dependent on the cultural factors and so, equally high in all the sampled cities.

Keywords: household waste; food waste; scrap; waste composition; annual income.

Introduction

The United Arab Emirates (UAE) is the most economically advanced country in the Middle East with a gross net income per ca pita at the end of 2020 of $36,284.6 [1]. Municipal solid waste (MSW) generation rates in the UAE are among the highest in the world, amounting to 6.67 million tons [2]. MSW generation per ca pita at its peak reached 2.1 kg/day but averages 1.8 kg/day. Sharjah is the third most significent emirate in the UAE with 1.685 million population [3], and produces 681,030 tons of MSW per year, which is equivalent to 404.17 kg / person. [4]. Only 6.76% of the total household waste is converted into secondary raw material (SRM) and 4.29% is converted to compost in Sharjah. The overall MSW management indicators in the UAE show that that only 20.76% of the household waste were recycled in 2019 despite the fact that by that time, 11 MSW treatment and sorting plants were up and running in all Emirates [5].

According to the State Statistics Service of Ukraine (UKRSTAT), about 500 million tons of waste are generated annually in Ukraine including primary industry waste (76%), secondary industry waste (about 18%), agricultural waste (about 2%), and MSW (approximately 2%). Thus, it can be argued that the Ukrainian industry accounts for up to 94% of all waste generated. The production of household and similar waste per capita showed continuous growth between 2014 and 2019 from 250 to 260.8 kg per capita [6]. According to the same source, a negligible percentage of this waste was recycled (less than 1%). Finally, the share of household and similar waste sent for incineration for electricity generation in Ukraine ranged from

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1.7% to 2.2% of all the generated quantity in the period from 2014 to 2018 [7].

Over a long period, scientific research were carried out to analyze the correlation between the rates of household waste generation and their composition, with various economic and social facts. For example, a study conducted in the capital of Botswana, Gaborone [8] concluded that low- and middle-income families produce more household waste than well-off families. A similar study in Dar Es Salaam led to different conclusion, where higher income households produced less waste with negligible metal content, this phenomena was explained with a hypothesis, that high income families use less canned food [9]. In a study that was conducted in Indonesia [10], no correlation was found between economic/social factors and MSW statistics. A recent similar study in Nigeria has shown that the amount of food waste in in the household waste was directly related to the lifestyle, and the content of packaging waste was depending on the economic well-being of consumers [11].

In Sharjah, a MSW morphology study was conducted in 2021 in accordance with the methodology of the United Nations Environment Protection (UNEP) program, which is the only trustworthy one available to the author from the UAE [5]. Over the past 10 years, various household morphology analyses in Ukraine have been carried out. Laznenko conducted a detailed study in 2019 [12]. A study was conducted in 2019, to find a relationship between the income of the residents in different cities of Ukraine and the composition of solid waste in these cities [13]. Finally, in 2018, the Japan International Cooperation Agency (JICA) conducted a household composition analysis in three Ukrainian cities - Kyiv, Kharkov, and Dnipro [14].

The aim of the article

The article aims at providing a comparative analyses of the household composition of selected Ukrainian cities and Sharjah then, assess whether the household annual income affects the waste composition.

Research results

To be able to provide the household waste composition comparative analysis, we summarize the results of each study separately starting with the composition of the waste in Sharjah (table 1).

Table 1. Result of household waste composition study in Sharjah

Waste component	Content percentage, %
Plastics bags	9.5
Metals	1.9
Carton	8.3
High density polyethylene (HDPE)	0.9
Paper	6.3
polyethylene terephthalate (PET), transparent	2.0
polyethylene terephthalate (PET), green	0.2
polyethylene terephthalate (PET), colored	0.03
Aluminium beverage cans	0.5
Foam	0.5
Polystyrene	2.5
Aluminium foil	0.6
Tetra Pak	0.5
Scrap wood	2.4
Glass	3.2
Textile	3.8
Polypropolyne (PP)	1.0
Polyvinyl Chloride (PVC)	0.1
Stones	2.6
Shoes, wires, ropes	0.9
Other	4.6
Food waste (fines)	47.7

The advantage of this study is the level of details and the number of components that household waste was divided into. The study indicated a very high content of food waste (47.7%), which is a comment result if no segregated collection system is implemented. The second component is the carton and paper with a combined percentage of 14.6%, plastics bags come third (9.5%) and hard packaging plastics come third with a percentage of 7.13%. The total plastics content in this study was found to be 16.73 which makes them the second largest component in the household waste composition in Sharjah.

The results of Lazarenko study are provided in table 2. This morphology study is interesting because it linked the household composition to the urbanization type.

Table 2. Result of household waste composition study - Lazarenko

	Vinnytsia region					Donetsk region			Poltava region			
Waste component	Regional center (story buildings), %	Regional center (private buildings), %	City (storey buildings), %	City (private buildings), %	Rural settlements, %	Private sector of large cities, %	Urban population of districts, %	Rural population of districts, %	Poltava city, %	Cities with population more than 5000, %	Large, urbanized areas, population between 1000 and 5000, %	Small size urbanized areas, population less than 1000, %
Food waste	43	39	44	43	33	42.6	52.5	35.4	40.1	24	14	19.3
Paper, karton	8	6	9	6	5	6	6.1	1.2	8	8	8	1.4
metals	1.5	3	2	1	2	4.5	2,4	0,9	1,2	1	2	3.8
Packaging polymers	11	7	10	9	7	7	6,6	1.4	10	13	13	7
Multi-layer packaging	ND	ND	ND	ND	ND	0,1	0,1	0	ND	ND	ND	ND
Scrap wood	ND	ND	ND	ND	ND	0,9	0,3	0.5	0.6	1.2	1.7	1,6
Textile	ND	ND	ND	ND	ND	2,8	3,1	0.1	3.2	3.5	5,9	2,1
Glass	9	11	8	14	10	4.3	8.3	5.5	14.5	18	17	24
Leather, rubber, bones	ND	ND	ND	ND	ND	1	0.6	0	1.3	3.1	5	3.1
Stones	ND	ND	ND	ND	ND	0.5	0.5	4.6	ND	ND	ND	ND
fines	ND	ND	ND	ND	ND	29.5	19.1	50.3	ND	ND	ND	ND
Hazard waste	0.7	0.6	1	1	1	0.7	0.5	0.1	0.7	0.6	0.8	0.7
Minerals, others	26.8	33.4	26	26	42	ND	ND	ND	20.5	27.8	32.6	37

The food waste content in the household waste in Poltava region was found to be the lowest, but in general, rural areas found to produce less food waste, this might be directly linked to their lifestyle. Urbanized cities were found to generate more plastics and packaging waste, which relates to their consumption behavior. In general, this analysis may indicate a link between social and economic conditions and household waste composition on the micro level.

The summary of Pavliuk's research in 8 Ukrainian cities is shown in table 3.

Table 3. Result of household waste composition study - Pavliuk

Waste component	Uzhhorod, %	Kherson, %	Nikopol, %	Cherkasy, %	Lviv, %	Odessa, %	Kharkiv, %	Kyiv, %
Food waste	48	40	29	38	26	67	33	38
paper, carton	12	12	40	7	10	5	22	13
Polymer packaging	12	20	5	19	13	8	11	10
Glass	5	3	6	11	4	4	9	13
Metals	2	4	4	2	2	1	3	1
Others	21	21	16	23	45	15	22	25

The fist observation in this analysis is the limited number of waste categories, which led to a considerable portion of the waste to be registered as “others”. The food waste was still evident to be the major household waste component however, its content varied from one city to other, it is believed that the main reason for this variation might be the fact, that some of the food waste was counted in the “others” portion. Paper, carton and plastics were found to be second and third largest components, which is in line with all the rest of the composition analysis.

The results of JICA household waste composition study in Kyiv, Kharkiv, and Dnipro are provided in table 4.

Table 3. Result of household waste composition study - JICA

Waste component	Kyiv, %	Kharkiv, %	Dnipro, %
Paper, carton	13.5	13.3	9
Food waste	44	50.8	46.5
Scrap wood	2.3	1.3	0.4
Textile	3.3	3.3	1.8
Polymers	21.5	11.6	20.4
leather, rubber	1.5	2.8	0.3
Metals	1.4	0.9	1.3
Glass	9.5	10.5	9.2
Vessels & stones	1.2	1.7	0.7
Others	1.8	3.8	10.4

The results were aligned with all previous research pertaining to the food waste content however, the content was found to be higher than in Pavliuk’s research. On the other hand, less paper and carton content was detected in Kharkiv, and the polymers were found to form much larger portion of the waste in Kyiv that in Pavliuk’s research. The fact that “others” category formed a very small part of the total waste composition in this study means that more thorough waste components segregation was conducted during the composition analysis, which makes it more trustworthy.

To construct a single unified master table that puts all the data required together and conduct further analysis, we will perform several manipulations. And so, due to the fact, that each composition study used its own way to identify components, some work was required to unify all of them under common categories. All types of plastics, regardless their function, were combined in one category the was called “plastics”. Vessels, stones, leather, rubber, bones, fines, minerals and other similar categories were grouped in “others”, the reason for that is the fact, that such types would anyway be part of the mixed waste category in any waste separate collection program. If the same category was provided more than one composition analysis research for the same city and had different values, the average number is considered in the master table and the “others” category is adjusted accordingly.

Wherever a morphology analysis ignored textile and scrap wood as separate household waste categories, it was decided to manually add them and consider their content equal to the average content of all other studies. The reason for doing that is the fact, that such categories do exist in the waste stream and not having them mentioned in the study as separate category only meant that they were combined with "others". When the same component, in the waste stream of the same city was counted for in one research and missed in the other, the percentage from the first research was copied into the other and deducted from "others" category. Multi-layer packaging and tetra pack were added to the "paper and carton" category, the reason for such decision is the fact, that multi-layer packaging and carton are usually collected and recycled using similar method. Finally, when hazard waste was separately categorized in the morphology analysis, it was added to "others" category, its content was extremely low in the household waste composition and shouldn't impose any adverse effect on the accuracy of the conclusions. The annual income per ca pita was per city in Ukraine and UAE were extracted from the official sources [15]; [1] and added to the final master table to ease the following correlation analysis. The results of all the above are presented in table 4.

Table 4. Compiled household waste composition analysis results

Regional center	Annual income, $/person	Food waste, %	Paper, cardboard, %	Metal, %	Polymers, %	Scrap wood, %	Textile, %	Glass, %	Other, %
Kyiv	6,967	41	13.25	1.2	15.75	2.3	3.3	11.25	11.95
Odessa	3,073	67	5	1	8	1.04	2.82	4	11.14
Poltava	3,024	25.1	6.35	2	10.75	1.28	3.68	18.38	33.46
Dnipro	3,678	46.5	9	1.3	20.4	0.4	1.8	9.2	11.4
Kharkiv	2,766	41.9	17.65	1.95	11.3	1.3	3.3	9.75	12.85
Vinnitsa	2,732	40.4	6.8	1.90	10.2	0.4	2.82	10.2	27.28
Lviv	2,773	26	10	2	13	1.04	2.82	4	41.14
Kherson	2,411	40	12	4	20	1.04	2.82	3	17.14
Cherkasy	2,482	38	7	2	19	1.04	2.82	11	19.14
Donetsk	1,652	43.5	4.5	2.9	5	0.57	2	6.03	35.5
Sharjah	36,285	47.7	15.1	3	16.73	2.4	3.8	3.2	8.77

Now that the master table is ready, correlation factors between the annual income and each household waste component were calculated and was conducted in two stages. In the first stage, all the cities were included but due to the fact that annual income in Sharjah was way higher than in any Ukrainian cities, it was decided to run another calculation exclusively for the Ukrainian cities (table 5).

The results of the calculations showed the following results:

a) weak positive correlation between the annual income and metal content, this might be related to the lifestyle and the habit of buying canned food but, this is only true if Sharjah is included in the calculations otherwise, when Sharjah data is excluded, a strong negative correlation is observed. This result can be explained if we understand the rapid lifestyle and culture in the UAE, where most of the population is imported workforce and the consumption of conserved food is a normal practice;

b) strong negative correlation is observed between annual income and paper and carton content but, again, when Sharjah data is excluded, the correlation disappears. This is a logic result because if we exclude the data from Kyiv, there is hardly a trend to establish between the paper and carton content in the household waste and the annual income per ca pita thus when we add the data from Sharjah then, we expect a huge surge in their content comparing to Ukrainian cities.

Table 5. Correlation coefficients between annual income and household waste components

	Food waste, %	Paper, cardboard, %	Metal, %	Polymers, %	Scrap wood, %	Textile, %	Glass, %	Other, %
Correlation coefficient	0.19	-0.40	0.30	0.24	0.67	0.50	-0.31	-0.28
Correlation coefficient for Ukrainian cities	0.05	-0.07	-0.45	0.29	0.70	0.32	0.27	-0.092

c) as textile and scrap wood data was partially edited manually during the process of creating the master table, the evident positive correlation between their content and the annual income may not be very accurate but on the other hand, the higher income families are expected to be spending more on their outfit, home appliances, and home renovation, these are assumed to be the source activities of textiles and wood waste;

d) positive correlation between the annual income and glass content in the household waste is indicated in Ukrainian cities, this correlation in reversed when Sharjah data is included. Taking into consideration, that UAE is a Muslim country and alcohol consumption is very limited, this result can be easily justified;

e) food waste in the household waste is high in Ukraine and UAE regardless of the annual income, it seems to be a cultural factor that is common between all the cities subject to this study.

Conclusions

Economic and social factors play a role in the composition of the household waste. The high content of food waste that is lost to waste seems to be a common phenomenon in the developing countries, where household source segregation practice is not widely ruled out. The content of such specific packaging material as glass is highly dependant on the cultural and religious, rather than financial factors. The lifestyle is a major factor that affects the content of textiles and scrap wood in the household waste as such types of waste reflect the tendency of the household owners to care about the public image and the interiors of their houses. The limited data and the different methods used in the morphology analysis may compromise the results and conclusions in this study however, these results and conclusions seem to fit in the daily life observations. The results can gain more credibility as more detailed composition studies are provided in different cities to have massive data with minimum error margin.

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СПІВВІДНОШЕННЯ МІЖ СКЛАДОМ ПОБУТОВОГО ВІДХОДУ ТА РІЧНИМ ДОХОДОМ – ПОРІВНЯЛЬНИЙ АНАЛІЗ МІЖ ВЕЛИКИМИ МІСТАМИ УКРАЇНИ ТА ШАРДЖА, ОАЕ

Анотація
Дана стаття присвячена дослідженню кореляції між складом побутових відходів і річним доходом на одного жителя в містах України та ОАЕ. Зібрані та уніфіковані результати аналізу морфології побутових відходів у великих містах України та місті Шарджа, співвіднесені з річним доходом мешканців. Було виявлено, що як фінансові, так і культурні чинники впливають на вміст кількох компонентів побутових відходів, у той час як вміст харчових відходів повністю залежить від культурних факторів і, таким чином, однаково високий у всіх містах, взятих у вибірку.

Ключові слова: побутові відходи; харчові відходи; брухт; склад відходів; річний дохід.

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