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RESEARCH PAPER

Household Dust from a City in Morocco: Characterization by Scanning Electron Microscopy

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ABSTRACT
Exposure to household dust is a common occurrence in all countries and causes various diseases. This study provided information on the number, shape, size distribution, and elemental composition of household dust particles collected in urban homes in Agadir city in Morocco. Moreover, a potential human health risk of exposure has been identified based on current research. Samples were analyzed using computer-controlled scanning electron microscopy and ImageJ image processing program. A total of 3296 particles were analyzed for their size, and 76 particles were classified according to their size and elemental composition. Household dust particles were classified in six types: micro-aggregates (31.6%), biogenic (5.3%), spherical (17.1%), subrounded (7.9%), subangular (11.8%), and angular (26.3%). These particles were determined to have originated from a distant source (Trask classification index between 1 and 2.5). They were large (Skewness asymmetry coefficient > 1), and ranged from 0.2 to 363 µm with an average value of 22.8 ± 0.6 µm in diameter. Dust particles with diameters of 5-10 µm and 10-20 µm were the most abundant, while dust diameters of 10-20 µm, 20-30 µm, and > 100 µm were the highest in volume. The domestic dust deposition rate was 19.8 ± 7.4 g/m^2 per year. Household dust is one of the major sources of PM_{10} in the residential environment (44.6% of the total number of particles), and the studied properties of house dust are highly related to human health. Household dust is a critical element to be considered in the occurrence of respiratory and cardiovascular infections.
Keywords: Indoor air; Particulate matter; Size distribution; Particle classification; Deposition rate.

INTRODUCTION

The World Health Organization (WHO) considers air pollution to be critical to public health. One in ten deaths is attributable to air pollution, and nine out of ten people live in urban areas exposed to poor air quality levels that exceed WHO guidelines. The indoor environment may be at least twice as polluted as the outdoor environment. The main pollutants in indoor air are particulate matter (PM), volatile inorganic compounds, and volatile organic compounds (VOCs). PM can come from combustion processes and from reactions between ozone, and certain VOCs (Carazo Fernández et al., 2013). These particles can be found in kitchens, bedrooms, offices, schools, and commercial complexes (Armendáriz-Arnez et al., 2010; Yip et al., 2017). PM exposure inside buildings is a significant risk factor (Morawska et al., 2017). PM with diameter less than 2.5 µm ($PM_{2.5}$), and fibers are able to penetrate into the

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respiratory tract (Carazo Fernández et al., 2013; Leung, 2015). Hence, unsafe indoor air quality impacts significantly both the respiratory and cardiovascular systems (Holgate, 2017). Furthermore, long-term exposure to PM can cause diseases due to subsequent respiratory and cardiovascular disorders (Carazo Fernández et al., 2013; Leung, 2015).

Natural or anthropogenic indoor dust is a source of indoor pollutants. Physical and chemical properties of indoor dust may explain the toxicity of particles and their negative impacts on the indoor environment as well as on human health (Moreno-Grau et al., 2001; Massey et al., 2013). Human contamination can be through the digestive, respiratory or dermal pathways (Meng & Lu, 2007). Risk for health also depends on their physical and chemical properties. Indeed, an organism's reaction will be determined by shape (Stearns et al., 2001), size (Stearns et al., 2001), elemental composition (Ljung et al., 2006; Wang et al., 2006), and interaction with surfaces of those particles (Hu et al., 2009). Household dust is one of the most common and widespread types of indoor dust that is generally found on the floors, walls, and roofs of residences (Yang et al., 2016). Numerous studies on household dust have been carried out on morphology, size distribution, mineralogical and elemental compositions, and deposition rate (Zhang et al., 2005; Morawska & Salthammer, 2006; Pipal et al., 2011; Habil et al., 2015). However, there is no research on household dust in Morocco.

Morocco, a country whose population generally is urban (60.4%), has recently undergone major economic development in sectors such as energy, transport, and industry. Economic activities are highly concentrated in coastal areas, thus increasing road traffic levels rapidly. For understanding house dust in Moroccan cities with rapid urbanization and economic development, Agadir city has been chosen for study. In this study, both morphology and size distribution of household dust were analyzed. To the best of our knowledge, this is the first study to report an analytical characterization of household dust in Morocco.

MATERIAL AND METHODS

Selected city was Agadir, a city in southern Morocco (30°25′12″ N, 9°35′53″ W, altitude above sea level: 31 m). It is the capital (chief town) of the Souss-Massa region, the second economic pole, and the first fishing port in the country, besides being a large commercial port.

Agadir is located on a narrow continental shelf that opens onto the Souss-Massa plain. It is limited by the Atlantic Ocean in the west, and by the mountain chain of the High Atlas in the north.

Agadir is geologically located on the "South Atlas accident" separating the High Atlas chain from the Anti-Atlas.

Agadir is known for its arid and semi-arid climate and counts almost eight dry months during a year. Annual average temperature is 17 °C, the average of the maxima of the hottest month is 27 °C, while the average of the minima of the coldest month is 7 °C. It is characterized by low rainfall (243.9 mm per year), significant cloudiness, high relative humidity, and low thermal amplitude. In winter, north and northwest winds bring precipitation and humidity, while south and southeast winds (Chergui) bring heat and dryness.

It is ranked as the fifth largest urban agglomeration in the country in terms of population. The major economic activity is the agri-food industry, and tourism. There are 420,248 people in the city, living in 105,057 households, four people on average living in each household. Housing is mainly modern Moroccan house type (concrete construction with one to three floors) (72.3%), and apartments in buildings of up to 5 floors (20.0%). Of these homes, 46.6% were built more than 20 years ago. All of them are equipped with kitchens, bathrooms, toilets, baths or showers, electricity, and water. Butane gas is practically used for cooking (99.3%). The most common ventilation mode is through windows and door openings. Motorized modes of travel account for 59% of total travel. Urban bus provides the same number of trips as small cabs (8% of the total). Public traffic is connected to the city center by radial ring lines.

Twelve samples were collected from twelve houses with interior floors, windows, and roofs. Household dust was extracted in dry state with fine hairbrushes (Yang et al., 2016). Household dust was collected without sieving. Stocked in labeled glass bottles, they were used to determine the morphology (shape and size), and elemental composition of the particles using a Scanning Electron Microscope with an electronic probe (MEB-EDS, JOEL/EO) at University Ibn Zohr, Agadir Faculty of Sciences. Collection area was 0.25 × 0.25 m^2.

SEM analysis is a reference method for morphology and particle size distribution (Yue et al., 2006; Pipal et al., 2011; Lee, 2019). Approximately 1 cm^2 of polycarbonate filter was cut and fixed on an aluminium SEM stub with a conductive plug, and then covered with a thin gold film (< 10 nm) to get a high-quality secondary electronic image. Such processes as sample movement, sample region selection, and scanning were controlled by computer.

Pictures were treated using ImageJ software, developed at the National Institutes of Health (NIH), USA. It is a Java-based public domain image processing and analysis program that is freely available, open source, multitasking, and platform independent. The area was automatically measured by the software by targeting each image particle. Data were then downloaded into LibreOffice Calc for further processing. From the particle surface area, the equivalent spherical diameter (EDS) was calculated as

$$EDS = 2 \times \sqrt{Area/\pi} \quad (1)$$

Trask's ranking index (S_0) was calculated to determine each sample's ranking. S_0 values were calculated as

$$S_0 = \sqrt{Q_3/Q_1} \quad (2)$$

with Q_1 is the first quartile, and Q_3 is the third quartile.

Skewness symmetry coefficient (S_k) was used to estimate the distribution towards coarse or fine particles, which is calculated as

$$S_k = Q_3 \times Q_1/Q_2^2 \quad (3)$$

where Q_2 is the median.

Long, middle, and surface axes of each particle were measured by ImageJ application to get the morphology parameters and the size of 3296 particles.

According the roundness value R_p, as calculated with ImageJ software using the formula

$$Rp = 4 \times Area/\pi \times (Majoraxis)^2 \quad (4)$$

Dust quantification using deposition rate in g/m^2 per year or g/m^2 per day could be used to evaluate various studies and/or environments. The household dust deposition rate was calculated in 26 urban houses from March 1, 2019, to March 31, 2020. This rate was calculated as

$$Rd = \frac{Wd}{S} \quad (5)$$

where Rd is household dust deposition rate (g/m^2 per year), Wd is household dust weight (g), and S is the collection area (m^2).

RESULTS AND DISCUSSION

The specific properties of the samples as determined by SEM, Trask's categorization index, and Skewness symmetry coefficient are shown in Table 1.

Table 1: SEM Sample Specifications, particles' Trask ranking index, and particles' Skewness symmetry coefficient

Sample ID	AVV (kV)[a]	Mag.[b]	Scale (μm)	SEM Particle count (1)[c]	ImageJ Particle count (2)[d]	Mean (μm)	S_0[e]	S_k[f]
e01	5,0	37	500	5	850	44.81	1.91	1.18
e02	1,5	120	100	6	645	21.03	1.72	1.04
e03	1,5	150	100	4	380	16.94	1.81	1.21
e04	1,5	300	50	4	335	10.39	1.74	1.13
e05	1,5	300	50	5	320	11.71	1.71	0.98
e06	15,0	650	20	2	141	3.52	1.82	0.97
e07	15,0	150	100	13	55	3.65	1.53	1.12
e08	15,0	6,000	2	6	160	26.90	3.13	0.68
e09	15,0	5,000	5	4	75	3.54	2.30	0.97
e10	15,0	1,300	10	11	75	23.59	1.81	1.42
e11	15,0	1,300	10	11	160	14.97	1.63	0.97
e12	15,0	2,000	10	5	100	2.87	1.57	1.24

e01: Anza Aloulya, e02: Adrar, e03: Echaraf, e04: Bouargane, e05: Dakhla, e06: Anza Aloulya, e07: Hay Mohammadi, e08: Alhouda, e09: El Farah, e10: Sidi Youssef, e11: Alwifaq1, e12: Essafa.
a: Accelerating voltage value.
b: Magnification.
c: Particle count was analyzed for elementary composition (a total of 76 particles).
d: ImageJ software particle count for size measurement (a total of 3296 particles).
e: Trask indice.
f: Skewness coefficient.

SEM analysis of household dust particles in study area were identified as microaggregate (31.6%), angular (26.3%), spherical (17.1%), subangular (11.8%), subrounded (7.9%), and biogenic (5.3%) forms (Table 2, Figure 1).

Table 2: Elemental composition of different morphological particles in household dust

Type	Sub-type	Pourcentage %	Morphology composition of each sub-type %					
			MA	BP	SRSP	SSP	SASP	ASP
K-rich	K-dominant	10.5	5.3			5.3		
	K + Cl	9.2	7.9		1.3			
	K + Al	5.3	2.6		1.3			1.3
	K + Si	1.3					1.3	
Si-rich	Si-dominant	10.5	1.3		1.3	1.3		6.6
	Si + Al	3.9	1.3		1.3		1.3	
	Si + K	1.3						1.3
Ca-rich	Ca-dominant	9.2	1.3			1.3		6.6
	Ca + Si	2.6	1.3				1.3	
	Ca + Cl	1.3	1.3					

Type	Sub-type	Pourcentage %	Morphology composition of each sub-type %					
			MA	BP	SRSP	SSP	SASP	ASP
	Ca + Al	1.3					1.3	
Al-rich	Al-dominant	9.2	3.9				1.3	3.9
	Al + Mg	2.6			1.3			1.3
	Al + K	1.3			1.3			
C-rich	C-dominant	11.8	1.3	2.6		5.3	2.6	
	C + Si	1.3				1.3		
Fe-rich	Fe-dominant	7.9	1.3			1.3		5.3
Zn-rich	Zn-dominant	3.9		2.6			1.3	
	Zn + Al	1.3	1.3					
Na-rich	Na-dominant	1.3					1.3	
Cu-rich	Cu + Al	1.3	1.3					
P-rich	P + Ca	1.3				1.3		
Total		100.0	31.6	5.3	7.9	17.1	11.8	26.3

MA: Micro-aggregates; BP : Biogenic particles; SSP : Spheric single particles; SRSP : Subrounded single particles; SASP : Subangular single particles; ASP : Angular single particles.

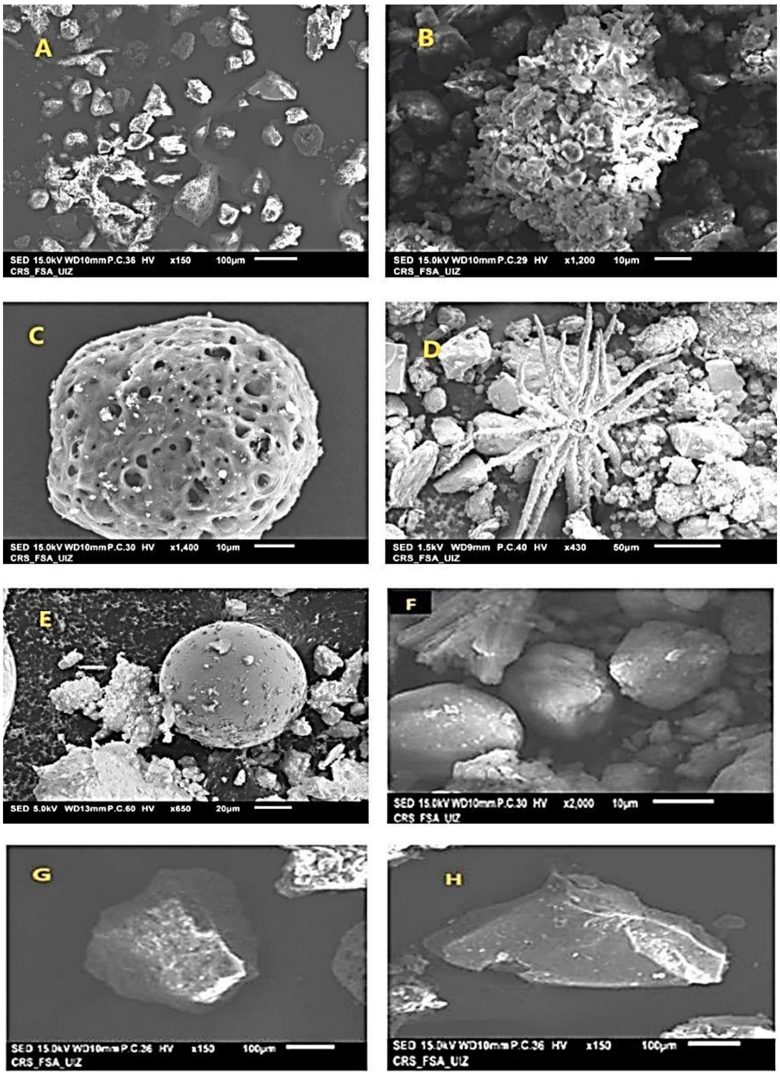

Fig 1. Scanning electron micrographs of urban household dust: A. Dust particles; B. Micro-aggregates; C, D. Biogenic particles; E. Spheric single particles; F. Subrounded single particles; G. Subangular single particles; H. Angular single particles

Particles that are angular, subangular, and subrounded have been categorized as mineral particles primarily derived from natural sources, such as soil dust, resuspension of road dust, and from some building construction activities. In this study, they represented 46.1%, a lower proportion than that found in Beijing, China, by Yang et al. (2016) in urban areas (over 80%). This may be considered in this study as an indication that household dust in Agadir could be primarily from an indoor environment.

Micro-aggregate particle was composed by a series of small mineral particles bound together (Figure 1B), which belong to the element types rich in K, Ca, Al, Si, C, Fe, Zn, and Cu (Table 2).

Mineral particles may have a marine source as a result of sea salt composition: Cl is associated with K (9.2%), and Ca (1.3%). Additionally, Al and Si elements as oxides are tracer aluminosilicates of earth's crust erosion phenomena. Fe and Cu elements could be generated by moving parts wear phenomena in a vehicle, mainly brake components (brake pads, and brake drums) (Lue et al., 2010). In addition, natural Zn can come from atmospheric transport of soil particles or by marine aerosol generation. Zn traces in sample 11 are mainly due as a result of vehicle body work, and paint shops. C, K, and Fe elements highlight the combustion phenomena through cooking and heating.

Carbonaceous part (11.8%) (Table 2) makes up most of the mass of particles, it comes mainly from the combustion source, and from vehicle source (Kocbach et al., 2005; Yue et al., 2006; Hu et al., 2009). During atmospheric transport, these particles can be physically associated with large particles such as sulfate (1.3%) (Li et al., 2013).

Some dust particles were biogenic, such as pollen fragments (Figure 1C) or organic fragments (Figure 1D), but accounted for only 5.3% of all particles. These biogenic particles contained mainly C and Zn.

Single spherical particles were rich in K, Si, Ca, C, Fe, and P (Figure 1E, Table 2). They can result from coal combustion at high temperatures, metallurgical manufacturing, automobile emissions, and cooking.

The other part of the subrounded particles belonged to the elements rich in K, Si, and Al. Their surfaces were mostly abraded (Figure 1F). These spherical mineral particles can be formed in more complex ways, such as secondary particles, long-range transport particles, and cosmic dust (Lue et al., 2010).

Single angular particles (Figure 1H) had acuminate angles and protruding edges that may have come from the outside and may not have been abraded over the long term. They were element types rich in K, Al, C, Fe, and Si, and made up 26.3% of the total (Table 2). Cl-rich particles could result from NaCl fixation.

Subangular particles rich in K, Si, Ca, Al, C, Zn, and Na. They are slightly abraded (Figure 1G).

The EDS spectra of 76 particles from the 12 samples are shown in Figure 2 and Figure 3.

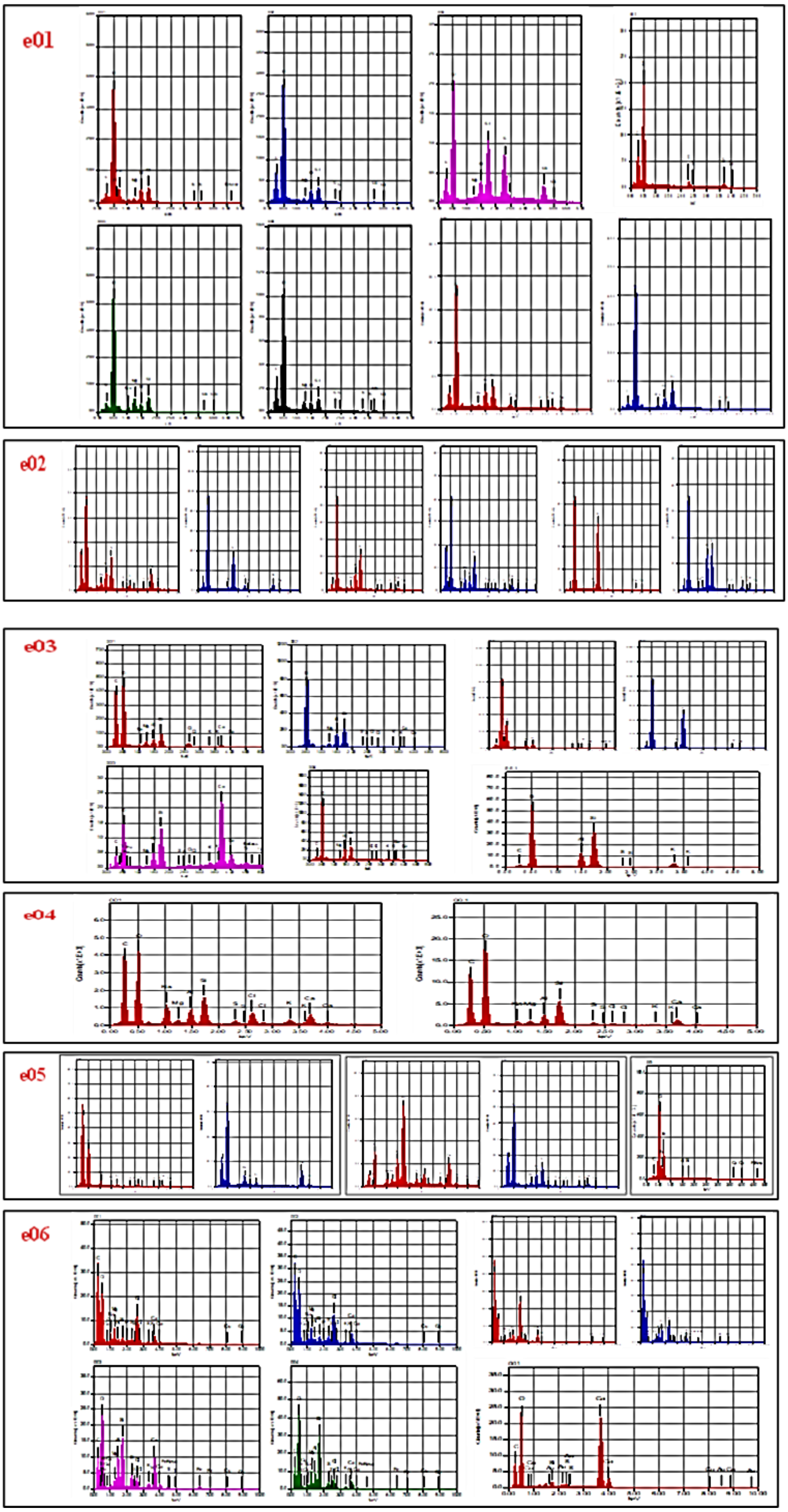

Fig 2: EDS spectra of samples: e01. Anza Aloulya; e02. Adrar; e03. Echaraf; e04. Bouargane; e05. Dakhla; e06.Anza Aloulya

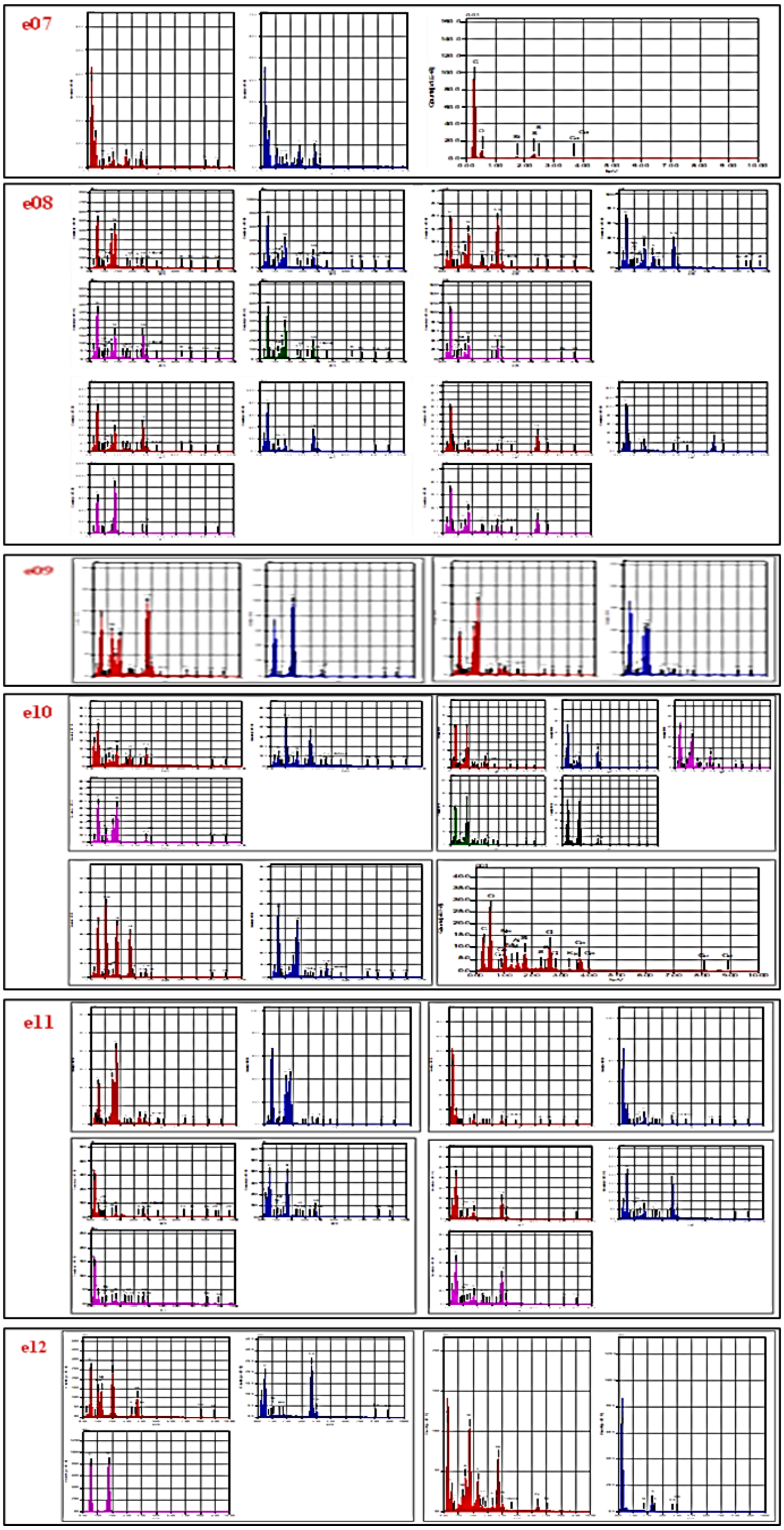

Fig 3: EDS spectra of samples: e07. Hay Mohammadi; e08. Alhouda; e09. El Farah; e10. Sidi Youssef; e11. Alwifaq1; e12. Essafa

Track ranking index (S_0) for most samples (11/12) was between 1 and 2.5 (Table1), these samples were highly classified, so they came from a very distant source. In fact, spherical particles represented 17.1 % of the total particle morphology, a proportion that is very high compared to that found by Yang et al. (2016). The 8th sample was only low classified ($3 < S0 < 4$), therefore the dust source originated nearby, especially from heavy road traffic.

Two thirds of the particles were coarse ($Sk > 1$) (Table1). Samples e01, e02, e03, e04, e07, e08, e10, and e12 were coarse, while samples e05, e06, e09, and e11 were thin.

The size of the 3296 particles ranged from 0.2 to 363 µm, with a mean value of 22.8 ± 0.6 µm. These particles have been well ranked (S_0 = 2.1), and were coarse (S_k = 3.4). It is possible that this may be attributed to the average household size in urban areas (4 on average), in addition to intense urban human activity. Let us note that the annual average wind speed in 2019 was 3.5 m/s (degree 3: light breeze according to the Beaufort scale). Soil and road particles can be blown into homes by the effect of the wind.

Particle sieve fraction in several studies ranged from 4 µm to 2 mm. Table 4 shows the size fraction distributions of urban household dust from several studies in several countries using various sampling methods. These size fractions are variable, and therefore comparison between studies is difficult. In this study, the fractions used in Yang et al. last study (2016) were adopted.

Table 4. Particle size distribution of urban household dust reported in recent studies

Study references	Location	Area study	Method	Fraction of the particle size (µm)	%
This study	Agadir, Morocco	12 urban houses	Dry sweeping without sieving	< 2,5 2,5 – 5 5 – 10 10 – 20 20 – 30 30 – 40 40 – 50 50 – 60 60 – 70 70 – 80 80 – 90 90 – 100 > 100	10.1 11.7 22.8 23.4 12.4 5.9 3.0 2.6 1.6 1.3 1.0 0.6 3.7
Yang et al. (2016)	Beijing, China	6 urban houses	Wet cleaning	< 2,5 2,5 – 5 5 – 10 10 – 20 20 – 50 > 50	2.0 13.7 26.4 30.6 24.1 3.2
Morawska et Salthammer. (2006)	USA	11 samples of household dust in kindergartens	Vacuum	< 63 63 – 2000	9.5 – 35.5 12,8 – 76,4
Bute et Heinzow (2002)	Germany	Urban houses	Vacuum	< 63 63 – 125 125 – 250 250 – 500 500 – 1000 1000 – 2000 > 2000	15.0 8.0 10.0 9.0 5.0 3.0 47.0

Study references	Location	Area study	Method	Fraction of the particle size (µm)	%
Mohave et al. (2000)	Aarhus, Denmark	7 office buildings	Vacuum	< 3	< 0.1
				3 – 6	0.1
				6 – 10	0.4
				10 – 25	6.3
				25 – 50	12.0
				50 – 125	41.0
				> 125	40.0
Lewis et al. (1999)	North Carolina, USA	25 urban houses	Vacuum	< 4	0.7
				4 – 25	20.0
				25 – 53	7.1
				53 – 106	22.7
				106 – 150	10.4
				150 – 250	12.7
				250 – 500	13.1
				500 – 2000	13.3
Seifert (1998)	Germany	Urban houses	Wet cleaning	< 30	0.3 – 24.0
				30 – 63	6 – 35
Hee et al. (1985)	Cincinnati, Ohio, USA	Urban houses	Vacuum/wet cleaning	< 44	18.0
				44 – 149	58.0
				149 – 177	4.5
				177 – 246	2.7
				246 – 392	6.1
				392 – 833	11.0

Particle size numerical distribution showed a positively asymmetrical curve with two peaks (Table 3). This distribution is sharper than normal ($S_k > 0$). The two peaks are between 5 and 10 µm and between 10 and 20 µm, representing 22.8% and 23.4% of the total number of particles in household dust, respectively. Similar distribution as found by Yang et al. (2016), but with lower proportions.

The second highest percentages were 11.7% and 12.4% for 2.5 to 5 µm and 20 to 30 µm particle size ranges, respectively.

Table 3. Particle size distribution of household dust by number and volume

Fraction of the particle size (µm)	Number percentage (%)	Volume percentage (%)
< 2,5	10.1	0.6
2,5 – 5	11.7	2.0
5 – 10	22.8	7.3
10 – 20	23.4	14.6
20 – 30	12.3	13.2
30 – 40	5.9	9.0
40 – 50	3.0	5.9
50 – 60	2.6	6.3
60 – 70	1.6	4.5
70 – 80	1.3	4.3
80 – 90	1.0	3.8
90 – 100	0.6	2.4
> 100	3.7	26.2
Total	100.0	100.0

PM2.5 and PM_{10} accounted for 10.1% and 44.6% of the total particles in household dust, respectively.

PM_{10} in this study is higher than that found by Yang et al. (2016), Bute and Heinzow (2002), and Mohave et al. (2000). Indoor household dust is therefore a source of PM_{10} in residential environments through resuspension, which can affect indoor air quality, and subsequently human health.

Particles smaller than 50 µm represented 89.2% of total household dust particles, a proportion lower than that found by Yang et al. (2016), and higher than those found by Morawska and Salthammer (2006), Bute and Heinzow (2002), Mohave et al. (2000), and Lewis et al. (1999). These differences are due to the sampling method and sampling location (Table 4).

Frequency volumetric distribution was uni-modal with a peak at diameters over 100 µm (26.2%). Volume particle size distribution of household dust was right asymmetrical (Sk > 0), and sharper than normal ($S_k > 0$) (Table 3). Compared to the peak of the number frequency of the grain size, the peak of the volume has moved to the right. That is because there is a high frequency of particles with a diameter over 100 µm (3.8%). PM_{10} accounted 9.9% of household dust by volume. Diameter particles smaller than 50 µm represented 52.5% by volume of household dust.

Particles with a diameter between 10 and 20 µm were the most numerous, a similar result to that of urban house dust in Yang et al. study (2016) study. Particle diameters over 100 µm were highest in volume, while in Yang et al. (2016) study, particles with diameters between 30 and 40 µm were the highest in volume. In addition, in this study, a percentage volume peak of household dust was observed at diameters over 100 µm. Whereas it was between 25 and 40 µm in Beijing. This difference in particle size distribution is mainly due to sampling (Morawska & Salthammer, 2006).

In this study, the household dust deposition rate was 19.8 ± 7.4 g/m^2 per year. Figure 4 shows the household dust deposition rates for several countries in urban houses (Adgate et al., 1995; Thatcher, 1995; Edwards et al., 1998; Meyer et al., 1999; Roberts et al., 1999; Seifert, 1998; Petrosyan et al., 2006; Yang et al., 2016). These rates ranged from 0.05 to 554.4 g/m^2 per year.

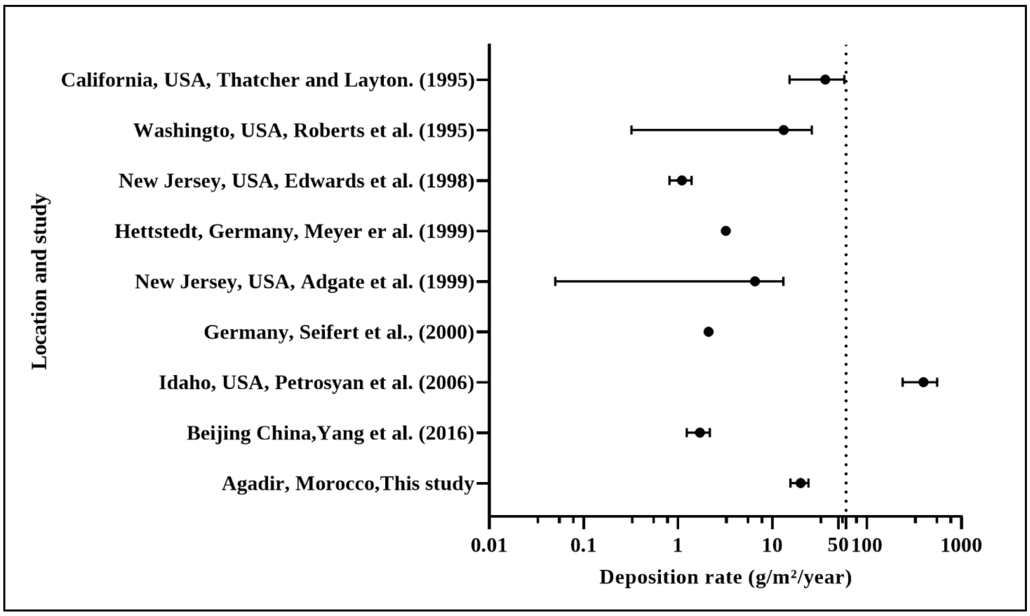

Fig 4: The deposition rate of the urban household dust (g/m^2 per year). The x-axis is on a logarithmic scale

Deposition rates for the studies cited in Figure 4 are less than 60 g/m^2 per year. Only Petrosyan et al. (2006) study in Idaho, USA, reported a range from 239.40 to 554.40 g/m^2 per year.

The rate calculated in this study is higher than those calculated in China (Yang et al., 2016), in Germany (Seifert, 1998), and in USA (Adgate et al., 1995; Edwards et al., 1998; Meyer et al., 1999; Roberts et al., 1999). Several factors may explain this finding, such as air exchange practices between indoors and outdoors depending on season (Edwards et al., 1998) (Opening windows is the most used way in Morocco). Furthermore, how many people live in the building, and how they clean it (Lewis et al., 2018; Meyer et al., 1999) (Generally, a Moroccan lodging is occupied by more than four people, and dry or wet sweeping is the most common practice for daily cleaning). Finally, the tightness of buildings (more than 40% of Moroccan houses are more than 20 years old). Note also that this rate depends upon the particles size and deposition surface properties (Morawska & Salthammer, 2006). In addition to the urbanization level, ongoing construction projects, and general traffic levels.

Human exposure to household dust may occur through ingestion, by inhaling resuspension fraction (Rasmussen et al., 2008), and by dermal contact through contact with surface dust (Morawska & Salthammer, 2006). Indeed, several researches have shown that household dust ingestion contributes significantly to overall dust exposure for various chemical elements such as brominated flame retardants (Larsson et al., 2018), some phthalates (Pelletier et al., 2017), polycyclic aromatic hydrocarbons, and lead (Glorennec et al., 2016). Dermal contact is minor compared to the ingestion, and inhalation tracts (Wormuth et al., 2006; Guo & Kannan, 2011; Bekö et al., 2013).

Moreover, particle size could affect human exposure tracts for household dust. However, PM_{10} are retained in lung bronchi, while those below 1 μm penetrate to the alveoli of the respiratory tract (Zhang et al., 2005), causing a systemic inflammatory response (Mukae et al., 2001), leading to chronic diseases such as cardiovascular disease (Husain et al., 2015).

However, dust particles that stick to the skin are variable in size, but the most frequently considered fraction is less than 150 μm (Ruby et al., 2016).

In this study, the number and percentage by volume of PM_{10} in urban household dust were 44.6% and 9.9%, respectively. Most particles are less than 150 μm in diameter. Thus, household dust is one of the major sources of inhalable particulate matter in urban residences. Subsequently, we cannot underestimate the risk of respiratory and cardiovascular disease in this population as a result of household dust exposure.

However, location and deposition level of particles in the human body is associated with their shape (Sturm, 2012). In this study, 46.1% of the particles were angular, subangular, and subrounded shapes. Moreover, these particles had respective surfaces larger than those of spherical particles with the same volume. Therefore, the surface contact area with human organs could be very large, and thus be more toxic (Schwarze et al., 2006).

Consequently, household dust morphology results could be used to assess indoor dust health risk (Yang et al., 2016).

CONCLUSION

The household dust from Agadir city in Morocco was collected to study the morphology, size distribution, mineral, and deposition rate. About half of the household dust particles had a subrounded, subangular, and angular morphology, corresponding to mineral particles.

Urban household dust particles were from a very distant source, they were coarser. Silicon, K, Ca, Al, and Fe were the predominant elements in household dust. Deposition rate of household dust is higher than that in China, Germany, and USA.

In urban areas, household dust may be generated mostly from indoor environments.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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