SUPPLEMENTARY MATERIAL

First evidence of microplastics occurrence in mixed surface and treated wastewater from two major Saudi Arabian cities and assessment of their ecological risk

Yolanda Picó[1*], Vasiliki Soursou [1], Ahmed H. Alfarhan[2], Mohamed A. El-Sheikh[2], Damià Barceló[2,3]

[1]Environmental and Food Safety Research Group (SAMA-UV), Desertification Research Centre CIDE (CSIC-UV-GV), Moncada-Naquera Road Km 4.5, 46113 Moncada, Spain

[2]Department of Botany and Microbiology, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia

[3]Water and Soil Quality Research Group, Department of Environmental Chemistry, IDAEA-CSIC, Barcelona, Spain

[*] Corresponding autor (Y. Picó)
E-mail address: Yolanda.Pico@uv.es

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Table S1. Concentration of Microplastics at Each Sampling Point of Riyadh and Al_Jubail (Items L^{-1})

City	Sampling site	R1	R2	R3	Average	SDs
Riyadh	A	4.9	4.7	5.2	4.9	0.20
	B	3.0	2.7	2.5	2.7	0.20
	C	5.1	5.6	4.6	5.1	0.38
	D	1.8	1.7	2.1	1.9	0.15
	F	2.2	2.4	1.7	2.1	0.30
Al-Jubail	G	0.2	0.2	0.2	0.2	0.03
	H	0.2	0.6	0.4	0.4	0.20
	I	0.2	0.1	0.2	0.2	0.04
	J	0.7	0.6	0.2	0.5	0.22

Table S2. Characteristics of MPs found in selected studies in different types of inland waters around the world.

Country	Total MPs	Water type	Polymers	Size	Color	Form	Ref.
Africa	2834–329,167 MPs/km^2 or *0.02–2.19* MPs/m^3	Lake Victoria (Uganda)	PE and PP	36 % < 1mm	White >Blue > Green	Fragments>flakes>filaments>film>foam	(Egessa et al., 2020)
Africa	mean of 705 particles m¯3	Urban stream (Johannesburg, South Africa)	----	---	White>Blue>Black	Filament> shaped objects> round> angular	(Dahms et al., 2020)
America (North)	230,000 particles/km2 (Ontario) and ~45,000 particles/km2	Lakes Eire and Ontario (Canada)	PE and PP	0.355–0.999 mm; 73%	-----	Fragments>pellets>fibers	(Mason et al., 2020)
America (North)	9000 to 40,000 particles/km2 or 0.07-0.29 particles m^3	Lake Superior (frontier between Canada and USA)	PE and PP	>333µm<4 mm	Bue>pink>white>silver>others	Fibers	(Minor et al., 2020)
America (North)	0.011-0.469 particles/m3	4 Oregon Rivers (USA)	___	200-5000 µm	___	Fibers>Fragments	(Valine et al., 2020)
America (North)	0.44–9.7 particles/m3	Lake Mead National Recreation Area (USA)	___	73.1% 355–1,000 µm 26.5% w 1,000–5,600 µm	clear (33.4%) > white (18.7%) > black (17.1%) > blue (14.7%) > red (6.7%).	Fibers (68.9%)>fragments (15.6%)> films (8.9%)> foams (6.5%)>beads/pellets (0.1%)	(Baldwin et al., 2020)
America (North)	1–2.75 microplastics/m3 across the estuary (>500 µm)	Hudson and Raritan Rivers (USA)	PE, PP and rubber	Two set 250-500 µm and 500-2000 µm	----	----	(Bailey et al., 2021)
America (Central)	0.72 -3425.26 MPs m−3	Rivers of Quito (Ecuador)	____	>0.3 µm	____	Fibers>Fragments>Films	(Donoso and Rios-Touma, 2020)
America (Central)	11.9 ± 0.6 to 61.2 ± 6.1 items m-3	Lake Porto Alegre (Brazil)	PP(54%)>PE (43.3%)>Other material (0.5%each)	100-250>250-500>5-100>500-1000>1000-3000	White transparent>Red>Blue≈Yelow >Green>Black)	Fragment>Fiber>microbead	(Bertoldi et al., 2020)
America (South)	0.9 ± 0.6 MPs m−3	Lakes across Patagonia	PET (38 %)>PU(11 %)>PP(2.9 %)>PS(2.9 %)	0.2-0.4 mm>0.4-0.6mm	Blue (42%)>Black (37%)	Fibers (67-96%)	(Alfonso et al., 2020)
Saudi Arabia	**160-700 particles m3 Al-Jubail , 1867-5018 Riyadh**	**Artificial channels**	**PE>PP>PS>PET**	**50-100 µm>100-250µm>250-500µm>500-1mm=<50µm>5 mm**	**white>red>blue>green>black**	**Fibers>fragments>spherules >others**	**This study**

Asia	0.0070 ± 0.0033 particles/m3 River, 0.0051 ± 0.0053 particles/m3 mangroves	Cherating river and mangroves, Malaysia	——	0.5-1>0.1-0.5>1.0-5><0.1mm	White>Transparent>black>others	Fragment>film>line>foam	(Pariatamby et al., 2020)
Asia	530 to 24,798 n/m3	Danjiangkou Reservoir (China)	PA, 24.8%>PE, 24.0%>PP, 17.1%	200–500 µm (61.4%)>500–1000 µm (20.7%)> 75–200 µm(10%)>1000 mm (7.9%)	transparent (42.8%)>brown (40.9%)>black (5.9%)> green (3.7%)>gray (3.3%)	Fragment>fiber>film>pellet> microbead	(Lin et al., 2021)
Asia	22,000 ± 5–14,000 ± 3 items/m^3	Manas River Basin (China)	PP (22.99%)> PET (20.69%) > PS (17.24%) >PE (16.09%)	1-0.3mm>0.3-0.1mm>2-1mm><1mm>5-2mm	White>black>transparency>red>blue	Fiber>Fragments>Films>Other	(Wang et al., 2021)
Asia	35 ± 5 MP/m3 to 1064 ± 90 MP/m3	Freshwater Poyang Lake (China)	PP, PVC, PE, PS, PVA	MPs (0.03–1 mm)	_____	fragments (30.2%)> films (17.2%)>fibers(29.3%)>foams (23.3%)	(Jian et al., 2020)
Asia	(130 ± 30) x 10^3 to (8500 ± 1241) x10^3 MPs/m^3 WWF (28.3 ± 4)x10^3 1 p/L reservoirs	Water bodies of Shangai megacity (China)	PP and PE	-------	-------	Granule (55%) and fiber (43%) accounted for the majority of shapes in WWF, whereas fiber was the majority (86%) in the outlet river water.	(Chen et al., 2020)
Asia	3.8 ± 0.4 MP m^3	Ganges River (India)	Rayon>acrylic>PET>PVC	>333 µm	--------	Fibres (91 %) and fragments (9 %)	(Napper et al., 2021)
Europe	0.3 to 618.5 items m-3	Mediterranean Rivers (France)	PP, PA, PVC, PS, PEVA, PET, PES, PUT, A	>333 µm	______	fibres> while fragments >spheres > and foils	(Constant et al., 2020)
Europe	≤4930 fibres·m-3	Inland Waters (Poland)	PET>PU>PS	< 1mm fibres 39 %	_______	Only fibers	(Kaliszewicz et al., 2020)
Europe	5.57 particles m-3	Elve River	PE>PP>PS	150–5000 µm	____	fibres> while fragments >spheres > and foils	(Scherer et al., 2020)
Europe	231 x 10^3 particles m^{-3}	Douro River (Portugal)	--------	Most <40 µm	-------	Fragment and fibers > spheres	(Prata et al., 2021)
Europe	0.15 particles.m^{-3}	Garonne River (France)	PE (44.5%), PS (30.1%) and PP (18.2%)	0.7 and 5 µm	White (32%), black (31 %), and blue (14 %)	Fibres not included	(de Carvalho et al., 2021)
Australia	0.40 ± 0.27 items/L	Goulburn River	PS>PA>Rayon	<1 mm 66 %	Blue>transparent	Fiber>Pellet	(Nan et al., 2020)
New Zealand	17–303 items m^{-3}	Cascades and streams	PE>PP	63-500 µm	Yellow>white/transparent	Fragment>Fiber>Film>Foam> pellet	(Dikareva and Simon, 2019)

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Table S3. Forms of Microplastics identified at Each Sampling Point of Ryadh and Al_Jubail (Items/L)

City	Site	R1	R2	R3	Mean	SDs	%	Mean %	RSD (%)
				Fibers					
Riyadh	A	3.1	2.2	3.8	3.0	0.80	62	59	5.2
	B	1.2	2.0	1.5	1.6	0.40	57		
	C	3.2	3.1	2.9	3.1	0.15	60		
	D	1.2	0.9	1.0	1.0	0.15	55		
	F	1.0	1.5	1.5	1.3	0.20	63		
Al-Jubail	G	0.2	0.1	0.09	0.1	0.04	58	60	2.1
	H	0.2	0.3	0.2	0.2	0.09	60		
	I	0.1	0.1	0.1	0.1	0.01	60		
	J	0.4	0.4	0.1	0.3	0.14	61		
							Total	**60**	**3.9**
				Spherules					
Riyadh	A	0.7	1.0	0.6	0.8	0.21	16	15	15.9
	B	0.4	0.5	0.4	0.4	0.06	16		
	C	1.0	0.9	0.8	0.9	0.10	18		
	D	0.3	0.25	0.34	0.3	0.04	16		
	F	0.4	0.3	0.01	0.2	0.20	11		
Al-Jubail	G	0.03	0.02	0.04	0.03	0.005	14	14	8.9
	H	0.07	0.05	0.07	0.06	0.012	16		
	I	0.05	0.01	0.03	0.02	0.013	13		
	J	0.12	0.07	0.01	0.07	0.055	13		
							Total	**15**	**13.3**
				Fragments					
Riyadh	A	0.6	0.9	0.6	0.7	0.173	14	15	14.6
	B	0.6	0.2	0.3	0.4	0.208	13		
	C	0.5	1.2	0.8	0.8	0.351	16		
	D	0.2	0.4	0.4	0.3	0.115	18		
	F	0.3	0.3	0.2	0.3	0.058	13		
Al-Jubail	G	0.03	0.04	0.02	0.03	0.008	14	15	8.5
	H	0.05	0.07	0.07	0.06	0.012	16		
	I	0.01	0.01	0.05	0.02	0.022	13		
	J	0.09	0.10	0.04	0.08	0.032	15		
							Total	**15**	**11.7**
				Other					
Riyadh	A	0.52	0.58	0.18	0.4	0.216	9	10	19.9
	B	0.78	0.02	0.78	0.5	0.439	10		
	C	0.39	0.37	0.59	0.4	0.122	8		
	D	0.16	0.17	0.12	0.5	0.026	11		
	F	0.42	0.34	0.41	0.5	0.044	12		
Al-Jubail	G	0.02	0.00	0.06	0.03	0.033	13	11	19.6
	H	0.12	0.18	0.04	0.11	0.070	10		
	I	0.05	0.00	0.02	0.02	0.023	11		
	J	0.11	0.03	0.01	0.05	0.053	10		
							Total	**10**	**16.7**

Table S4. Colors of Microplastics identified at Each Sampling Point of Ryadh and Al_Jubail (Items/L)

City	Site	R1	R2	R3	Mean	SDs	%	Mean %	RSD (%)
					White/Transparent				
Riyadh	A	2.1	1.9	2.1	2.0	0.12	41	38	20
	B	1.2	1.1	1.0	1.1	0.10	40		
	C	2.0	3.0	1.9	2.3	0.62	45		
	D	0.7	0.7	0.0	0.5	0.41	25		
	F	0.9	1.0	0.7	0.8	0.15	40		
Al-Jubail	G	0.1	0.1	0.1	0.1	0.02	40	43	15
	H	0.1	0.3	0.2	0.2	0.10	40		
	I	0.1	0.1	0.1	0.1	0.02	53		
	J	0.3	0.2	0.1	0.2	0.11	40		
							Total	**40**	**18**
					Red				
Riyadh	A	1.23	1.50	1.30	1.3	0.14	27	25	3.9
	B	0.75	0.68	0.62	0.7	0.06	25		
	C	1.27	1.39	1.16	1.3	0.11	25		
	D	0.45	0.43	0.52	0.5	0.05	25		
	F	0.55	0.61	0.43	0.5	0.04	25		
Al-Jubail	G	0.13	0.04	0.05	0.07	0.05	37	28	20.9
	H	0.04	0.16	0.10	0.10	0.06	25		
	I	0.05	0.03	0.05	0.04	0.01	25		
	J	0.18	0.15	0.05	0.13	0.06	25		
							Total	**27**	**14.6**
					Blue				
Riyadh	A	0.98	0.94	1.04	1.0	0.050	20	20	1.5
	B	0.60	0.60	0.50	0.6	0.059	21		
	C	1.02	1.11	0.93	1.0	0.092	20		
	D	0.36	0.34	0.42	0.4	0.038	20		
	F	0.44	0.49	0.34	0.4	0.073	20		
Al-Jubail	G	0.05	0.00	0.05	0.03	0.028	16	19	11.6
	H	0.03	0.13	0.08	0.08	0.048	20		
	I	0.05	0.00	0.05	0.03	0.029	22		
	J	0.14	0.10	0.05	0.10	0.045	19		
							Total	**20**	**7.4**
					Green				
Riyadh	A	0.20	0.20	0.20	0.2	0.000	4	4	13.1
	B	0.15	0.14	0.12	0.1	0.013	5		
	C	0.25	0.28	0.23	0.2	0.023	4		
	D	0.05	0.05	0.10	0.1	0.029	4		
	F	0.10	0.10	0.05	0.1	0.029	4		
Al-Jubail	G	0.05	0.00	0.00	0.02	0.029	8	7	13.2
	H	0.00	0.05	0.05	0.03	0.029	5		
	I	0.00	0.00	0.05	0.02	0.029	11		
	J	0.05	0.00	0.00	0.02	0.029	3		
							Total	**6**	**13.1**
					Black				
Riyadh	A	0.15	0.20	0.20	0.18	0.030	4	5	31.9

	B	0.10	0.15	0.15	0.13	0.029	5		
	C	0.15	0.17	0.14	0.18	0.014	4		
	D	0.05	0.05	0.05	0.13	0.002	7		
	F	0.10	0.10	0.05	0.08	0.029	4		
Al-Jubail	G	0	0	0	0	0	0	0	0.0
	H	0	0	0	0	0	0		
	I	0	0	0	0	0	0		
	J	0	0	0	0	0	0		
							Total	**5**	**31.0**
Other									
Riyadh	A	0.1	0.1	0.05	0.2	0.003	4	1	39.8
	B	0.2	0.2	0.2	0.2	0.029	4		
	C	0.5	0.2	0.2	0.05	0.002	4		
	D	0.05	0.00	0.00	0.03	0.029	4		
	F	0.00	0.00	0.00	0.05	0.000	4		
Al-Jubail	G	0	0	0	0	0	0	0	
	H	0	0	0	0	0	0		
	I	0	0	0	0	0	0		
	J	0	0	0	0	0	0		
							Total	**4**	**39.8**

Table S5. Size of Microplastics identified at Each Sampling Point of Ryadh and Al_Jubail (Items/L)

City	Site	R1	R2	R3	Mean	SDs	%	Mean %	RSD (%)
					<50 µm				
Riyadh	A	0.4	0.6	0.5	0.5	0.09	10	10	1
	B	0.2	0.3	0.2	0.3	0.05	10		
	C	0.4	0.7	0.5	0.5	0.14	10		
	D	0.1	0.2	0.2	0.2	0.04	10		
	F	0.2	0.3	0.2	0.2	0.07	10		
Al-Jubail	G	0.0	0.0	0.0	0.0	0.00	10	10	5
	H	0.0	0.1	0.0	0.0	0.03	11		
	I	0.0	0.0	0.0	0.0	0.00	10		
	J	0.1	0.1	0.0	0.0	0.03	10		
						Total		**10**	**3**
					50-100 µm				
Riyadh	A	1.6	1.7	1.9	1.7	0.14537	35	35	0.2
	B	1.0	1.0	0.9	1.0	0.05685	35		
	C	1.6	2.1	1.7	1.8	0.23731	35		
	D	0.6	0.6	0.7	0.7	0.08769	35		
	F	0.7	0.9	0.6	0.7	0.14557	35		
Al-Jubail	G	0.1	0.1	0.1	0.07	0.009	35	35	2.0
	H	0.1	0.2	0.1	0.14	0.093	36		
	I	0.1	0.0	0.1	0.05	0.014	35		
	J	0.2	0.2	0.1	0.17	0.087	35		
							Total	**35**	**1.2**
					>100-250 µm				
Riyadh	A	1.23	1.12	1.40	1.3	0.139	25	25	0.4
	B	0.75	0.65	0.67	0.7	0.049	25		
	C	1.27	1.33	1.25	1.3	0.043	25		
	D	0.45	0.41	0.56	0.5	0.077	25		
	F	0.55	0.59	0.46	0.5	0.062	25		
Al-Jubail	G	0.06	0.04	0.05	0.05	0.011	25	25	1.2
	H	0.04	0.15	0.11	0.10	0.057	25		
	I	0.05	0.02	0.05	0.04	0.013	26		
	J	0.18	0.14	0.05	0.12	0.063	25		
							Total	**25**	**0.8**
					>250-500 µm				
Riyadh	A	0.74	0.61	0.88	0.7	0.136	15	15	1.5
	B	0.45	0.35	0.42	0.4	0.048	15		
	C	0.76	0.72	0.79	0.7	0.033	15		
	D	0.27	0.22	0.35	0.3	0.066	15		
	F	0.33	0.32	0.29	0.3	0.019	15		
Al-Jubail	G	0.04	0.02	0.03	0.03	0.008	15	15	2.8
	H	0.02	0.08	0.07	0.06	0.031	15		
	I	0.03	0.01	0.03	0.02	0.009	15		
	J	0.11	0.08	0.03	0.07	0.036	14		

							Total	**15**	**2.0**
		>500-1000 µm							
Riyadh	A	0.49	0.42	0.57	0.494	0.074	10	11	19.3
	B	0.30	0.24	0.27	0.272	0.027	10		
	C	0.51	0.50	0.51	0.494	0.005	10		
	D	0.18	0.15	0.23	0.272	0.038	15		
	F	0.22	0.22	0.19	0.210	0.018	10		
Al-Jubail	G	0.02	0.01	0.02	0.020	0.005	10	10	0.0
	H	0.02	0.06	0.04	0.039	0.021	10		
	I	0.02	0.01	0.02	0.016	0.006	10		
	J	0.07	0.05	0.02	0.049	0.024	10		
							Total	**10**	**31.0**
					>1000 µm				
Riyadh	A	0.2	0.2	0.3	0.24	0.054	5	7	45.4
	B	0.1	0.1	0.2	0.15	0.035	5		
	C	0.3	0.2	0.3	0.24	0.042	5		
	D	0.1	0.1	0.1	0.15	0.020	8		
	F	0.1	0.1	0.0	0.26	0.003	12		
Al-Jubail	G	0.0	0.0	0.0	0.01	0.004	5	5	58.3
	H	0.0	0.0	0.0	0.01	0.010	4		
	I	0.0	0.0	0.0	0.01	0.004	5		
	J	0.0	0.0	0.0	0.03	0.009	7		
							Total	**6**	**41.1**

Table S6. Sn of the different polymers according to Lithner et al. (2011), average % of each polymer found in this study, and average values of HI

Polymer	Sn (category)	Mean % of polymers	HI
PP	1 (II)	26	26
PE	10.5 (II)	21	220.5
PS	30 (II)	19	570
PET	4 (I)	16	64
Total Value	**Categor III**		**881.45**

Table S7. Calculation of PLE at each sampling point and for each city

		Items/L	Cfi	VCFi =PLE	Site	
Riyadh	A	4.92667	33	33	3565609	20
	B	2.72667	18	18		
	C	5.09333	34	34		
	D	1.86667	12	12		
	F	2.12000	14	14		
Al-Jubail	G	0.20000	1	1	12	2
	H	0.40000	3	3		
	I	0.15333	1	1		
	J	0.50000	3	3		