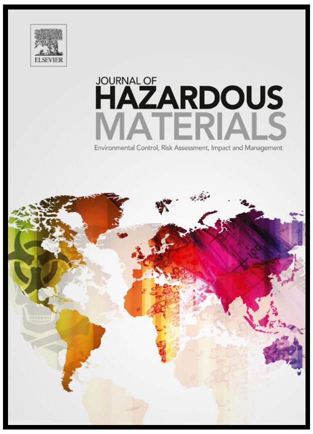
Journal Pre-proof



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, Vasiliki Soursou, Ahmed H. Alfarhan, Mohamed A. El-Sheikh, Damià Barceló

PII: S0304-3894(21)00711-1

DOI: https://doi.org/10.1016/j.jhazmat.2021.125747

Reference: HAZMAT125747

To appear in: *Journal of Hazardous Materials*

Received date: 20 December 2020
Revised date: 18 March 2021
Accepted date: 20 March 2021

Please cite this article as: Yolanda Picó, Vasiliki Soursou, Ahmed H. Alfarhan, Mohamed A. El-Sheikh and Damià Barceló, First evidence of microplastics occurrence in mixed surface and treated wastewater from two major Saudi Arabian cities and assessment of their ecological risk, *Journal of Hazardous Materials,* (2020) doi:https://doi.org/10.1016/j.jhazmat.2021.125747

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

Abstract

In this study, water of the channels and ponds that conduct residual water in two most important cities of Saudi Arabia were assessed to ascertain the influence of the population on the occurrence and pollution characteristics of microplastics (MPs) (>20 µm in size). Riyadh has 5,188 million inhabitants and is an urban city even though also have industry while Al-Jubail has only 0.77 and is the biggest industrial city. MPs showed an average of 3.2 items/L in Riyadh and 0.2 items/L in Al-Jubail showing a statistically significant difference between both cities. Sampling with a Turton Tow Net of 20-µm mesh, fibers were dominant in all sites (60 %). MPs size was mainly distributed between 80 and 250 µm (60 %), and their major colors were white (40 %), red (25 %) and blue (20 %). Infrared spectral analysis revealed that most of the selected particles were identified as MPs of polypropylene and polyethylene (48.3%). The risk assessment was carried out using both the hazard index (HI) and the pollution load index (PLI). The results showed that, in this case, the decisive index is the PLI since the main difference in the MPs characteristics between the two cities is their concentration.

Keywords

Microplastics; Al-Jubail; Riyadh; Surface water; Ecological risk

1. Introduction

The excessive use of plastic in our society is a fact (Barceló and Picó, 2019). Since plastic is not biodegradable or usually recycled properly, it ends up accumulating in the aquatic environment, especially but not only in the marine ecosystems (Abayomi et al., 2017). Although there is no standardized definition of microplastics (MPs), the most widely reported criterion is a maximum size of 5 mm as well as its most common classification is in primary (directly release into the environment) and secondary (produced by mechanical wear of plastics) (da Costa et al., 2016; Picó and Barceló, 2019; Prata et al., 2021b). de Souza Machado et al. (2018) warned that the occurrence of MPs on soils, sediments and surface waters could pose a long-term negative effect on ecosystems worldwide. Main sources of MPs to these aquatic ecosystems are larger plastic items, treated or untreated wastewater and runoff of several origins, e.g. industrial, agricultural, storm water, etc. (Pico et al., 2019; Prata et al., 2020). The growing presence of MPs has raised awareness and increased legislative, social and scientific initiatives to reduce the use of plastics through a more responsible consumption and to remove them from water once have reached it (Prata et al., 2020; Prata et al., 2019; Rodrigues et al., 2019). However, MPs have been widely found in a variety of inland aquatic ecosystems including rivers, lakes and groundwater, even though they have been much less studied than in the marine environment (Baldwin et al., 2020; Bertoldi et al., 2020; Nan et al., 2020; Scherer et al., 2020; Wang et al., 2021a; Zobkov et al., 2020). MPs can cause different toxic effects when ingested by the aquatic biota due to its mechanical action or to the intrinsic or extrinsic compounds that are able to release (Baalkhuyur et al., 2018; Filella et al., 2020; Wang et al., 2021b). Several studies identified megacities as a hotspot of MPs contamination (Bailey et al., 2021; Chen et al., 2020; Napper et al., 2021). However, the hydrological, morphological, and anthropogenic features of impacted surface waters are quite different throughout the world and extrapolation is unreliable (de Carvalho et al., 2021; Prata et al., 2021a).

Commonly in arid and semi-arid areas, this waste water is channeled or accumulated in artificial ponds and is widely used for the artificial recharge of aquifers, to maintain the ecological flow of several surface water ecosystems of great biodiversity, to create recreational areas for the population's leisure or for several of these reasons together (DeNicola et al., 2015). However, little is known on the fate of MPs released that could accumulate in artificial aquatic environments, such as lagoons, ponds, pools and channels. Only Edo et al. (2020) examined MPs occurrence in sediments of artificially and non-artificially recharged lagoons from a network of endorheic wetlands noting that the recharge of lagoons with wastewater effluents could not be a sustainable practice. Similarly, Picó et al. (2020) reported a density of MPs >250 µm in irrigation channels that end at the Al-Asfar and Al-Hubail Lakes in Saudi Arabia comparable to that reported all around the world. Up to our knowledge, no more studies on the occurrence of MPs in artificial aquatic systems have been published.

Saudi Arabia is one of the largest markets for food packaging in the middle east (valued at USD 8.07 billion in 2019) and uses 40 kg of plastic bags per inhabitant each year – almost 20 times the global average measured by the European Union (EU) (Alharbi et al., 2020; Oteef and Elhassan, 2020). Limited studies reported the occurrence of MPs in coastal areas (Abayomi et al., 2017; Ruiz-Compean et al., 2017), marine environments (Al-Salem et al., 2020a; Kor and Mehdinia, 2020) and natural wetlands (Álvarez-Ruiz et al., 2020; Picó et al., 2020) of Saudi Arabia. They covered transport and its numerical modelling, fate and distribution (Alosairi et al., 2020), as well as, their accumulation in fish intended for human consumption (Al-Salem et al., 2020b; Baalkhuyur et al., 2018; Baalkhuyur et al., 2020). These studies did not provide information on the contribution of MPs from artificial surface channels that, as a counterpart, are the main source of MPs to groundwater or to the sea.

In this paper, the occurrence, abundance and distribution of MPs in artificial channels and ponds located under the influence of two Saudi Arabia cities, Riyadh and Al-Jubail was assessed. Riyadh is the capital of Saudi Arabia located on the Najd plateau in central Saudi at 24° 38' N and 46° 43' E and at 650 m a.s.l. with total area 4900 km^2. The climate is characterized by hot, dry summers (average temperature 47°C) and mild winters but with temperatures ranging from -2°C at night to 22°C during the day, with all precipitation falling (55 mm). Riyadh is an important financial, business, and manufacturing centre with 7.6 million people, which can consume a huge plastic material and also has industrial areas producing large quantities of plastic material. Al-Jubail city is located on the Arabian Gulf of east Saudi, at 27.00° N 49.66° E and 12 m a.s.l. It is the largest petrochemical industrial zone in the world, with an area of 1,016 km^2 in which plastics and plastic resins and synthetic fibers are manufactured, among many other products. The average annual temperature is 33.5 °C, the climate is milder with temperatures of 40 °C in summer and 10 °C in winter, and annual rainfall is 88 mm. It has a population of 778.600 inhabitants and has industrial complexes, large ports and port facilities (Siddiqi et al., 2016). This knowledge will improve our understanding of the extent and magnitude of MPs pollution in artificial freshwater systems (ponds and channels) feeding with residual waters in hyper arid areas. This study is up to our knowledge the first assessment on the occurrence of MPs in these artificial areas under the influence of major Saudi Arabia cities. The ecological risks of MPs were estimated adopting two already proposed indexes: hazard index (HI) according to Lithner et al. (2011) and the pollution load index (PLI). The research results of the two methods are supplemented to illustrate whether the two methods are scientific and acceptable.

2. Experimental

2.1. Research area and sampling

Water samples were collected from 5 sampling stations in Riyadh on 24 and 25 February, 2019 and four in Al-Jubail 26 and 27 February, 2019 (see **Fig. 1** or go to https://www.google.com/maps/d/u/1/edit?mid=1z7HN1YWu94YVnRu06dbln3ACPOuIWZdq&usp=sharing for a zoomable version of the map). Generally, 2 to 3 stations were sampled per day and the duration of each sampling was approximately 4 h. Of the 5 sampling stations set in Riyadh, three of them are located in the 40 km canal that carries wastewater from the large industrial areas and the effluent from the Al-Hayer wastewater treatment plant (south of Riyadh) to an artificial pond. The first two points A and B (24º35’42.72” N, 46º50’48.48”E and 24º32’54.45”N, 46º55’22.96”E, respectively) were downstream of the discharges from two major industrial areas and the third C (24°22'51.98"N, 46°53'37.39"E) near the pond. A fourth point D (24°22'15.31"N, 46°54'17.08"E) was in the same pond and finally the fifth F

(24°18'57.42"N, 47° 3'4.72"E) in a downstream channel. This area was previously studied in 2017 (Picó et al., 2020) for emerging contaminants and these points showed an attenuation gradient. In Al-Jubail, the four sampling points H (27° 6'9.75"N, 49°34'15.79"E), G (27° 6'34.93"N, 49°34'34.35"E), I (27° 7'4.39"N, 49°34'20.79"E) and J (27° 7'22.06"N, 49°34'0.88"E) were equidistant along the runoff channels system that crosses longitudinally the city and transports treated water from different industries (El-Sorogy et al., 2018). In terms of weather conditions, there was no rainfall in Saudi Arabia during the whole month of February, the weather was sunny to cloudy in Riyadh and sunny in Al-Jubail and temperatures on sampling days ranged between 16 and 24ºC in Riyadh and between 18 and 21ºC in Al-Jubail.

Each sample was collected from the surface water (a depth of 0–30 cm) using a stainless-steel sampler (2.5 L) provided by Yjingrui (Zhengzhou, China). A total of 20 L of water was collected per sample at each sampling site and pass through a Turton Tow Net 30 cm in mounth and 105 cm in length (20 µm Nitex® mesh) of Starlab® (Yulee, FL, US). Three replicates were collected at each sampling site. In the canals, waterways, and pools, water samples were collected from points near the shore by increasing the length of the sampling rod or from a nearby bridge due to water flow or depth. Once passed through the Turton net, the residues on the net were rinsed with distilled water and stored with water in 50 mL glass jars. The samples were transported to the laboratory and stored at low temperature (4 °C) in the dark prior to further analysis.

2.2. Extraction, Determination and Quality Assurance.

The extraction was performed adapting the general schema of the method established by NOAA Technical Memorandum NOS-OR&R-48 (Masura et al., 2015). That is, once in the laboratory, the collected 50 mL water samples were initially filtered using a glass microfiber filter (GF/F, 0.45 µm, Whatman®). Then, filter cake was transferred to a glass conical flask (500 mL) and treated with 20 mL of 0.05 M iron (Fe(II)) solution and 20 mL 30% hydrogen peroxide (Fenton reagent) at a temperature 60-80 ºC for a variable time (ranging for 2 to 12 h depending on the organic matter content). The resulting extract, was filtered again through MF-Millipore® Membrane Filter, 0.45 µm pore size, gridded, 4.7 mm of diameter. The filter paper was placed into a glass petri dish, dried at low temperature (60ºC) and observed into a stereomicroscope (Model EZ4, Leica AG, Wetzlar, Germany). The MPs were then visually identified and quantified at two magnifications (8× and 35×) in order to discriminate smaller ones. MPs were manually counted and classified according to the shape (fragment, spherules, fibers and others), color (white, red, green, blue, black and other) and size (<50, 50-100, >100-250, >250-500, >500-1000 and >1000-5000 µm).

The chemical composition of MPs was studied in those with a size between 0.5 and 5 mm, which were susceptible to be taken with tweezers from the filter paper and collected separately in vials. Then, of each filter, about 15 MPs (in Riyadh samples) and about 1 in Al-Jubail samples were analyzed by a FTIR spectrometer (Jasco FT7 IR) with an Attenuated Total Reflectance (ATR) adapter in the range of 400–4000 cm^{-1}, with 50 scans at a resolution of 10 cm^{-1}. The total of MPs analyzed by each set of samples was about 52 items. In total, taken into account that samples were taken in triplicate about 156 suspected MPs items were analyzed varying slightly according to the filter.

Several precautions were taken to avoid contamination in the laboratory and in the field. In both, the researchers avoided using clothing with textile materials able to release easily fibers. In the laboratory, a work area with minimal air currents was selected to avoid air deposition, all liquid reagents including water and washing solvent were filtered to remove potential materials (GF/C, 1.2 µm, Whatman®) and the glass materials and instruments used were successively washed with ultrapure water and methanol and covered with aluminum foil. Laboratory blanks were prepared by passing 10 L of ultrapure water through the filter paper with the aid of a vacuum and examined under the stereomicroscope. In the field, blanks were also obtained at each city by passing 20 L of ultrapure water, which was transported, from the laboratory to the sampling site in 2.5 L glass bottles. Regardless of the results, only some fibers were found in field (3 fibers in one of the filters and 2 in other) and in procedural blanks (as an average 1 fiber per filter were found ca. 0.1 items/L). Laboratory and procedural blanks, subjected to the same procedures as samples allowed to control airborne and cross contamination improving the method's quality.

2.3. Risk assessment

Risk assessment was performed using HI that takes into account the chemical toxicity of each type of MP polymers to the ecological environment and PLI that considered the amount of MPs.

The HI was calculated as:

$$HI = \sum Pn \; x \; Sn \qquad (1)$$

where P_n is the percent of MP polymers extracted at each sampling site, and S_n is the hazard score of the plastic polymer. The S_n were obtained from Lithner et al. (2011).

The PLI initially proposed for heavy metals (Tomlinson et al., 1980) was defined as:

$$CFi = \frac{C_i}{C_{0i}}$$

$$PLI = CF_i \quad (2)$$

$$PLI_{zone} = \sqrt[n]{(PLI_1 x PLI_2 x \ldots x PLI_n)}$$

CF_i is the quotient of the concentration (C_i) of MPs at each sampling site and the minimum MPs concentration (C_{0i}), which is a defined value (represented in this study, by the minimum concentration of MPs). PLI at each sample site is equal to CF_i is the MPs are considered as a whole. The PLI in each Saudi Arabian city (PLI_{zone}) was calculated as the n-root from the n-PLIs obtained for each one of the stations.

In order to compare and to combine both, the HI and PLI values were shorted into four levels categories (I–IV) in which the hazard increases according to the criteria outlined in **Table 1,** which is based on the UN Globally Harmonized System (GHS).

Table 1. Risk level categories for microplastic pollution according to the EU

	Risk level categories			
	I	II	III	IV
Value of the polymer index (HI)	<10	10–100	100–1000	>1000
Value of the pollution load index (PLI)	<10	10–20	20–30	>30

2.4. Statistical analysis

The MPs abundance in artificial water was expressed as items L^{-1}. The data are shown as mean ± standard deviation of three different samples and were recorded and drawn using Microsoft Excel 2016. The data were subjected to analysis of variance and independent sample t-test using the IBM® SPSS® statistics 26 software package (IBM; Armonk, New York) and differences at $p < 0.05$ were considered statistically significant.

3.-Results and discussion

3.1. Occurrence and distribution of MPs

MPs were detected at all selected sampling points. **Fig. 2** illustrates the occurrence of MPs in both cities, Riyadh and Al-Jubail, as well as the percentage of fibers and other shapes (see **Table S1** for data detailed for each sample taken in triplicate). Considering the global results, MPs concentrations ranged from 1.9 ± 0.15 items/L to 5.1 ± 0.38 items/L in Riyadh with an average 3.2 ± 0.2 items/L and from 0.2 ± 0.3 items/L to 0.5 ± 0.22 items/L in Al-Jubail with an average 0.2 ± 0.1 items/L (**Table S1**). The concentration of MPs in Riyadh (1.9 -5.1 items L^{-1}) was significantly higher than that in Al-Jubail (0.2-0.5 items L^{-1}) ($p < 0.05$). The predominant shape was fibers with a constant percentage among the different points. The number of MPs in these cities is also higher than that found in previous study carried out in the Al-Hassa area in Saudi Arabia (Álvarez-Ruiz et al., 2020; Picó et al., 2020). Both studies are not comparable due to the different size of the nets used —in Al-Hassa, 333 µm and in this study 20 µm. Up to our knowledge, there are no more studies performed in inland waters of Saudi Arabia to compare.

The amount of MPs found in this study was compared to those found over the world (see **Table S2**, first column). MPs concentrations in Al-Jubail are within the range found in other aquatic ecosystems, such as, urban streams of South Africa (Dahms et al., 2020) and New Zealand (Dikareva and Simon, 2019), Mediterranean Rivers (Constant et al., 2020) or lakes under the influence of large cities (Bertoldi et al., 2020). Contrarily, values are much higher than those reported in lakes (Alfonso et al., 2020;

Baldwin et al., 2020; Egessa et al., 2020; Minor et al., 2020), mangroves (Pariatamby et al., 2020) and rivers (Nan et al., 2020; Pariatamby et al., 2020; Scherer et al., 2020; Valine et al., 2020) of less anthropized areas. Instead, MPs concentration in Riyadh is only comparable to the results reported in inland waters of Poland (Kaliszewicz et al., 2020) (where casually the samples were also taken with a mesh of 20 µm) or Rivers that receive high percentage non treated wastewater (Donoso and Rios-Touma, 2020; Jian et al., 2020). Some studies in reservoirs and rivers of China showed higher MPs concentrations (Lin et al., 2021; Wang et al., 2021a). These studies performed in sites with a moderate anthropic influence reported a mesh size similar to that of our study. This is proof that the comparison of results suffers from some problems due to the variety of pore sizes of the mesh used to sampling MPs. In the studies reported in **Table S2**, the sizes of the mesh range from 20 µm (as in the present study) to 333 µm. Although this factor has a clear influence on some results, there is a clear relationship between the abundance of MPs and the existence of large urban settlements, confirmed by the results of this study. The economic type and the development mode of the city also have influence in the results. Then, cities with the same population but different characteristics can show different amount and patterns of MPs pollution. The higher concentrations of MPs in Riyadh than in Al-Jubail can also be due to their differences. Several studies suggest that commercial/public/recreational and heavy industrial land uses contribute more plastic pollutants to aquatic environments than other land uses (Bailey et al., 2021; Chen et al., 2020; Napper et al., 2021). Complementarily, other studies suggested that the spatial variation in MPs concentration was driven by urbanization (de Carvalho et al., 2021; Prata et al., 2021a).

The comparison of MPs concentrations with samples sites of the same location showed differences (Fig.2) not statistically significant ($p>0.05$). Sampling sites from Riyadh includes the wastewater from the South WWTPs and some plastic industries, specially surrounding location A. The point C also showed an increase in the MPs content that can be due to the presence of other small wastewater treatment plant. However, in addition to these sources, it is possible that part of the MPs found are due to the waste (bottles, food containers, bags) left by visitors, as the water pool has become a recreational area (location C). The pond decrease the MPs concentrations. Interestingly, Lin et al. (2021) who study MPs distribution in the water column of the largest reservoir in China, showed that MPs settled from the surface and accumulated in the middle layer of the reservoir, which can explain the MPs behavior observed in this study since samples were taken in the surface.

The samples in Al-Jubail were taken from the water run-off canal system that mainly transports water from occasional rainfall and flooding, functioning also as a channel for treated water that is discharged from different industries and destined for industrial re-use. There are also differences between the MPs concentrations in the several sampling sites but, as happened in Riyadh, these differences are not statistically significant (see **Fig.2**).This channel receives before point J the discharge of a WWTPs (urban and industrial), and before the point I the discharge of WWTPs that treats mostly water from industrial origin. These two points showed the higher concentrations even through MPs concentration was highly homogeneous in this area and no big differences were observed. Chen et al. (2020) indicated that drainage systems aggravate MPs pollution due to overflow in wet weather or during rain events, but during periods of drought MPs are more likely to settle in sewer sediments decreasing their concentration. This could also explain the lower concentration found in Al-Jubail.

3.2. Physical characteristics of the MPs

The MPs photographs collected in a stereomicroscope from all the sampling sites in this study indicated the presence of four MP forms (fiber, spherules, fragments and others). The photos in **Fig. 3** presents spherules (a-c) fragments (d-f) and fibers (g-i) selected to illustrate the most representative forms and colors. Some photos present impurities because the main problem in isolating MPs from a surface water sample is to remove interfering organic matter. Oxidation with Fenton's reagent used in this process does not provide complete digestion because some organic materials are resistant to it, but more drastic oxidation processes can alter the integrity of the MPs (Briggs et al., 2019). These figures show in many cases MPs with rough surfaces with eroded fissures and contours, indicating that have undergone intense wear through the several environmental compartments. The variety of shapes and colors indicates different origins.

Fibers, white of transparent with a size <100 µm were the dominant morphology. **Fig. 4A** shows fibers as the prevailing MP shape in Riyadh and Al-Jubail (59 % and 60%, respectively), followed by spherules and fragments (both at 15 % in both cities), and other 10 % (detailed information in **Table S3**). Many sources of fiber release to the environment have been reported, including laundry, use and wear of plastic products (sanitary towels, masks, bags, etc.), and plastic waste generated in industrial production (Cesa et al., 2020; Ó Briain et al., 2020; Pico et al., 2019). Fibers were prevalent at all sampling sites in the very narrow range from 58 to 64 %. Many studies in urban streams (Dahms et al., 2020), lakes (Alfonso et al., 2020; Baldwin et al., 2020; Minor et al., 2020) and rivers (Constant et al., 2020; Donoso and Rios-Touma, 2020; Nan et al., 2020; Scherer et al., 2020; Valine et al., 2020; Wang et al., 2021a) report fibers as the prevalent MPs shape. Particularly, Napper et al. (2021) reported 91 % of fibers in the

Ganges River. Contrarily, other studies report fragments as the most common MPs shape (Bertoldi et al., 2020; Dikareva and Simon, 2019; Jian et al., 2020; Lin et al., 2021; Mason et al., 2020; Pariatamby et al., 2020). Several studies related the elevated presence of fibers to the presence of effluents from wastewater treatment plants (Chen et al., 2020; Prata et al., 2021a).

Fig. 4B shows the proportion of MPs white/transparent, red, green, and black and others. White (40 % of the samples), red (20 %) and blue (20 %) were the dominant colors **(Table S4)**. The similarity in the MP colors between the cities does not mean that the pollution source was the same ($p > 0.05$). This pattern of colors are partly in agreement with other MPs studies where white and blue colors are the most frequent colors in MPs samples (Dahms et al., 2020; Egessa et al., 2020) or white, blue, pink or even red (Bertoldi et al., 2020; Minor et al., 2020).

Finally, **Fig. 4C** illustrated those MPs with a size >50 µm and < 1 mm (85 % of the total) are main MPs in all sampling sites (detailed information in **Table S5**). In fact, there are not statistical significant differences between sampling sites within each city. This agree with those cited in other studies (Alfonso et al., 2020; Baldwin et al., 2020; Bertoldi et al., 2020; Egessa et al., 2020; Lin et al., 2021; Mason et al., 2020; Nan et al., 2020; Wang et al., 2021a). The most abundant range of MPs size is between 50 -100 µm (35 %) and between 100-250 µm (25 %). This result differs from those of other authors showing clearly that the fraction of MPs between 100-250 µm and even the fraction between 250-500 µm are more abundant than MPs with a size <100 µm. The differences between this and other studies can be due to the different mesh sizes used in the different studies.

3.3. Chemical characterization of microplastics

Chemical characterization of MPs was performed using a FTIR spectroscopic system. This system can be only applied to MPs size range between 500 µm and 5 mm because MPs are visible to the human eye and can be separated of the filter with a tweezer. This means that considering the number reported in the experimental section, as an average 15 % of the MPs identified by visual inspection were analyzed by FTIR. The separation of MPs is not easy and requires patience, good eyesight and a firm hand. The total number of particles collected for this chemical analysis was 152 corresponding to a range of 5-15 for each sample taken in Riyadh and of 1-2 for the Al-Jubail ones. Of the total samples, approximately 18 % of the particles visually identified as MPs could not be confirmed by its chemical composition. These unidentified polymers correspond mostly to fibers. The percentage of synthetic fibers identified in this study is higher than that reported by Prata et al. (2021a) that found mostly natural (62.6%), followed by unidentified (23.0%), with only 14.4% of synthetic fibers. However, these authors also reported the higher levels of synthetic fibers in surface water highly impacted by effluents of the wastewater treatment plants. In this study only 15 % of the total MPs where confirmed by FTIR, then in other size range the synthetic fibers percentage could be lower. Only 4 polymer types, PP, PE, PET and PS were identified based on a comparison with infrared spectrogram databases. The small percentage of MPs analyzed indicates that there may be other MPs, but in any case, those identified must have an important relevance. The FTIR for PP and PE are displayed in **Fig. 5(a)**. The proportions of the 4 MPs polymer types are presented in **Fig. 5(b).** PP (28 %), PE (19 %), PS (18 %) and PET (16 %) were the average percentages of each type MP detected in Al-Jubail. In Riyadh, PE (24 %) and PP (22 %) were at the highest percentages, followed by PS (20 %) and PET (16 %). Although the study areas present different degrees of MPs contamination, the types of polymers detected are similar in type and proportion, demonstrating some correspondence in MPs pollution sources. PP is widely used in packaging (food, pipes, and chemical containers), consumer goods (luggage, toys), automotive industry (battery boxes and trays, bumpers), fibers, and fabrics (clothing, blankets and other fiber-based products). PE —the most widely produced plastic in the world— is used for film, hollow products, fibers and everyday needs (e.g., plastic bags). PET, also known as polyester, is converted into fibers, fabrics, films for packaging and automotive parts. PS is mainly used as foam, but also as a traditional plastic and is transformed into disposable lunch boxes, trays and packaging boxes, soundproofing materials, handicrafts, etc.

A comparison of the results from this study with other studies of different types of waters shows some similarities as well as variations. The most common trend of polymer abundance (as observed in **Table S2**) is to show indistinctly PE and PP as the major polymers (Bertoldi et al., 2020; Constant et al., 2020; Dikareva and Simon, 2019; Egessa et al., 2020; Jian et al., 2020; Mason et al., 2020; Minor et al., 2020; Scherer et al., 2020; Wang et al., 2021a). Many of them, include PS as a quite frequent polymer (Constant et al., 2020; Jian et al., 2020; Kaliszewicz et al., 2020; Nan et al., 2020; Scherer et al., 2020; Wang et al., 2021a). These polymers are widely present in a range of products such as plastic bags, plastic films, containers and plastic food packaging that could be major contributors to MPs presents in the environment.

3.4. Risk assessment of MPs

There are no harmonized procedures for conducting a risk assessment of MPs contamination and many of the methods used were initially proposed for heavy metals and further translate to MPs (Lin et al., 2021; Peng et al., 2018; Xu et al., 2018).

MP polymers have a certain toxicity in their own right, and the different toxic effects of polymers vary depending on their chemical components. **Fig.6** presents the HI based on formula (1) for the different sampling sites. The S_n as previously mentioned were obtained from Lithner et al. (2011) and are reported in **Table S6** together with the average percentage of each polymer and the average HI obtained. In this study, the percentages of each polymer found at each sampling location were similar and therefore obtained HI values have small variations and are very similar in both areas. The average HI index for the polymers is 881 that would be in the Category III indicating a moderate risk to the environment due to the toxic characteristics of the polymers. This classification in different categories is well-supported by toxicity data and assays reported for the monomers according to the UN Globally Harmonized System (Lithner et al., 2011). However, HI does not have into account concentration.

One of the principles of toxicology stated by Paracelsus establishes that the dose makes the poison. Then, the concentration of MPs find at each sampling point is also important. The significant difference between the concentrations of MPs found in Riyadh and in Al-Jubail would mark a difference in the risk assessment. The PLI value of each sampling site was calculated according to formula (2), and the results are shown in **Fig. 7** and **Table S7**. The differences in concentrations between both cities indicates that MPs in Riyadh would be within the Category III also indicating potential for acute toxicity since both the toxicity and amount fall in this category. However, in the case of Al-Jubail, concentrations are in the Category I, indicating a very low risk to the aquatic biota. The risk level criteria for this is less clear since it was extrapolate from metal studies. However, these categories are supported by the study of Jung et al. (2020) who assessed the risk posed by MPs seawaters through own and literature exposure studies. A predicted no-effect concentration (PNEC) of 12 particles/L was derived by employing a species sensitivity distribution approach, which is in agreement with the categorization by PLI.

4.- Conclusions

Surface water samples taken at Riyadh and Al-Jubail contained MPs, with varying abundance depending on the city. The abundance of MPs in Riyadh was significantly higher than in Al-Jubail. The shape, size and color of the MPs collected in both cities did not vary significantly. Fibers were dominant in both cities. The MPs collected in this study were mainly small-sized particles, with a large proportion distributed in the 50-100 µm size range. Moreover, this study identified four types of polymers through Fourier transform infrared spectroscopy (FTIR). PP and PE were the dominant polymer types in both cities. By utilizing certain mathematical approaches for the evaluation of the ecological risk of different research areas and different seasons, it is possible to identify the pollution status of the research area and accurately estimate the MPs in the environment. For instance, in Riyadh, there is a potential ecological risk due to MP abundances, as already mentioned, since it was considered risk category III. This would mean in practice a loss of biodiversity in the aquatic environment that may affect plants and biota in pools, irrigation channels and oasis irrigated with mixed surface and treated wastewater from Riyadh. This study can be used as a reference to understand better the impacts of MPs in artificial surface channels and ponds affected by the discharges of wastewater treatment plant. Lastly, we would like to add that samples were collected in 2019 before the Covid-19 outbreak. Our intention is to continue our study by determining the abundance and type of MPs in the same areas following Covid-19 as the increase in the manufacture and use of face masks (which are made of plastic materials) worldwide has already shown that it has increased the amount of plastic waste. This will allow us to better investigate and understand the negative environmental effects of the increasing use of plastic during 2020 pandemic.

Acknowledgments

The financial support from the project number (RSP-2020/11) King Saud University, Riyadh, Saudi Arabia.

References

Abayomi OA, Range P, Al-Ghouti MA, Obbard JP, Almeer SH, Ben-Hamadou R, 2017. Microplastics in coastal environments of the Arabian Gulf. Marine Pollution Bulletin 124, 181-188. https://doi.org/10.1016/j.marpolbul.2017.07.011.

Al-Salem SM, Uddin S, Al-Yamani F, 2020a. An assessment of microplastics threat to the marine environment: A short review in context of the Arabian/Persian Gulf. Marine Environmental Research 159, 104961. https://doi.org/10.1016/j.marenvres.2020.104961.

Al-Salem SM, Uddin S, Lyons B, 2020b. Evidence of microplastics (MP) in gut content of major consumed marine fish species in the State of Kuwait (of the Arabian/Persian Gulf). Marine Pollution Bulletin 154, 111052. https://doi.org/10.1016/j.marpolbul.2020.111052.

Alfonso MB, Scordo F, Seitz C, Mavo Manstretta GM, Ronda AC, Arias AH, et al., 2020. First evidence of microplastics in nine lakes across Patagonia (South America). Science of the Total Environment 733, 139385. https://doi.org/10.1016/j.scitotenv.2020.139385.

Alharbi NS, Qattan MY, Alhaji JH, 2020. Towards sustainable food services in hospitals: Expanding the concept of 'plate waste' to 'tray waste'. Sustainability (Switzerland) 12, 6872. https://doi.org/10.3390/SU12176872.

Alosairi Y, Al-Salem SM, Al Ragum A, 2020. Three-dimensional numerical modelling of transport, fate and distribution of microplastics in the northwestern Arabian/Persian Gulf. Marine Pollution Bulletin 161, 111723. https://doi.org/10.1016/j.marpolbul.2020.111723.

Álvarez-Ruiz R, Picó Y, Alfarhan AH, El-Sheikh MA, Alshahrani HO, Barceló D, 2020. Dataset of pesticides, pharmaceuticals and personal care products occurrence in wetlands of Saudi Arabia. Data in Brief 31, 105776. https://doi.org/10.1016/j.dib.2020.105776.

Baalkhuyur FM, Bin Dohaish E-JA, Elhalwagy MEA, Alikunhi NM, AlSuwailem AM, Røstad A, et al., 2018. Microplastic in the gastrointestinal tract of fishes along the Saudi Arabian Red Sea coast. Marine Pollution Bulletin 131, 407-415. https://doi.org/10.1016/j.marpolbul.2018.04.040.

Baalkhuyur FM, Qurban MA, Panickan P, Duarte CM, 2020. Microplastics in fishes of commercial and ecological importance from the Western Arabian Gulf. Marine Pollution Bulletin 152, 110920. https://doi.org/10.1016/j.marpolbul.2020.110920.

Bailey K, Sipps K, Saba GK, Arbuckle-Keil G, Chant RJ, Fahrenfeld NL, 2021. Quantification and composition of microplastics in the Raritan Hudson Estuary: Comparison to pathways of entry and implications for fate. Chemosphere 272, 129886. https://doi.org/10.1016/j.chemosphere.2021.129886.
Baldwin AK, Spanjer AR, Rosen MR, Thom T, 2020. Microplastics in Lake Mead National Recreation Area, USA: Occurrence and biological uptake. PLoS ONE 15, e0228896. https://doi.org/10.1371/journal.pone.0228896.
Barceló D, Picó Y, 2019. Microplastics in the global aquatic environment: Analysis, effects, remediation and policy solutions. Journal of Environmental Chemical Engineering 7, 103421. https://doi.org/10.1016/j.jece.2019.103421.
Bertoldi C, Lara LZ, Mizushima FAdL, Martins FCG, Battisti MA, Hinrichs R, et al., 2020. First evidence of microplastic contamination in the freshwater of Lake Guaíba, Porto Alegre, Brazil. Science of The Total Environment, 143503. https://doi.org/10.1016/j.scitotenv.2020.143503.
Briggs E, de Moura EAB, Furusawa HA, Cotrim MEB, Oguzie EE, Lugao AB, 2019. Microplastics: A Novel Method for Surface Water Sampling and Sample Extraction in Elechi Creek, Rivers State, Nigeria. Springer International Publishing, Cham, pp. 269-281.
Cesa FS, Turra A, Checon HH, Leonardi B, Baruque-Ramos J, 2020. Laundering and textile parameters influence fibers release in household washings. Environmental Pollution 257, 113553. https://doi.org/10.1016/j.envpol.2019.113553.
Chen H, Jia Q, Zhao X, Li L, Nie Y, Liu H, et al., 2020. The occurrence of microplastics in water bodies in urban agglomerations: Impacts of drainage system overflow in wet weather, catchment land-uses, and environmental management practices. Water Research 183, 116073. https://doi.org/10.1016/j.watres.2020.116073.
Constant M, Ludwig W, Kerhervé P, Sola J, Charrière B, Sanchez-Vidal A, et al., 2020. Microplastic fluxes in a large and a small Mediterranean river catchments: The Têt and the Rhône, Northwestern Mediterranean Sea. Science of the Total Environment 716, 136984. https://doi.org/10.1016/j.scitotenv.2020.136984.
da Costa JP, Santos PSM, Duarte AC, Rocha-Santos T, 2016. (Nano)plastics in the environment - Sources, fates and effects. Science of the Total Environment 566-567, 15-26. 10.1016/j.scitotenv.2016.05.041.
Dahms HTJ, van Rensburg GJ, Greenfield R, 2020. The microplastic profile of an urban African stream. Science of The Total Environment 731, 138893. https://doi.org/10.1016/j.scitotenv.2020.138893.
de Carvalho AR, Garcia F, Riem-Galliano L, Tudesque L, Albignac M, ter Halle A, et al., 2021. Urbanization and hydrological conditions drive the spatial and temporal variability of microplastic pollution in the Garonne River. Science of The Total Environment 769, 144479. https://doi.org/10.1016/j.scitotenv.2020.144479.
de Souza Machado AA, Kloas W, Zarfl C, Hempel S, Rillig MC, 2018. Microplastics as an emerging threat to terrestrial ecosystems. 24, 1405-1416. 10.1111/gcb.14020.
DeNicola E, Aburizaiza OS, Siddique A, Khwaja H, Carpenter DO, 2015. Climate Change and Water Scarcity: The Case of Saudi Arabia. Annals of Global Health 81, 342-353. https://doi.org/10.1016/j.aogh.2015.08.005.

Dikareva N, Simon KS, 2019. Microplastic pollution in streams spanning an urbanisation gradient. Environmental Pollution 250, 292-299. https://doi.org/10.1016/j.envpol.2019.03.105.
Donoso JM, Rios-Touma B, 2020. Microplastics in tropical Andean rivers: A perspective from a highly populated Ecuadorian basin without wastewater treatment. Heliyon 6, e04302. https://doi.org/10.1016/j.heliyon.2020.e04302.
Edo C, González-Pleiter M, Tamayo-Belda M, Ortega-Ojeda FE, Leganés F, Fernández-Piñas F, et al., 2020. Microplastics in sediments of artificially recharged lagoons: Case study in a Biosphere Reserve. Science of The Total Environment 729, 138824. https://doi.org/10.1016/j.scitotenv.2020.138824.
Egessa R, Nankabirwa A, Ocaya H, Pabire WG, 2020. Microplastic pollution in surface water of Lake Victoria. Science of The Total Environment 741, 140201. https://doi.org/10.1016/j.scitotenv.2020.140201.
El-Sorogy A, Al-Kahtany K, Youssef M, Al-Kahtany F, Al-Malky M, 2018. Distribution and metal contamination in the coastal sediments of Dammam Al-Jubail area, Arabian Gulf, Saudi Arabia. Marine Pollution Bulletin 128, 8-16. https://doi.org/10.1016/j.marpolbul.2017.12.066.
Filella M, Hennebert P, Okkenhaug G, Turner A, 2020. Occurrence and fate of antimony in plastics. Journal of Hazardous Materials 390, 121764. https://doi.org/10.1016/j.jhazmat.2019.121764.
Jian M, Zhang Y, Yang W, Zhou L, Liu S, Xu EG, 2020. Occurrence and distribution of microplastics in China's largest freshwater lake system. Chemosphere 261, 128186. https://doi.org/10.1016/j.chemosphere.2020.128186.
Jung J-W, Park J-W, Eo S, Choi J, Song YK, Cho Y, et al., 2020. Ecological risk assessment of microplastics in coastal, shelf, and deep sea waters with a consideration of environmentally relevant size and shape. Environmental Pollution, 116217. https://doi.org/10.1016/j.envpol.2020.116217.
Kaliszewicz A, Winczek M, Karaban K, Kurzydłowski D, Górska M, Koselak W, et al., 2020. The contamination of inland waters by microplastic fibres under different anthropogenic pressure: Preliminary study in Central Europe (Poland). Waste Management and Research 38, 1231-1238. https://doi.org/10.1177/0734242X20938448.
Kor K, Mehdinia A, 2020. Neustonic microplastic pollution in the Persian Gulf. Marine Pollution Bulletin 150, 110665. https://doi.org/10.1016/j.marpolbul.2019.110665.
Lin L, Pan X, Zhang S, Li D, Zhai W, Wang Z, et al., 2021. Distribution and source of microplastics in China's second largest reservoir - Danjiangkou Reservoir. Journal of Environmental Sciences (China) 102, 74-84. https://doi.org/10.1016/j.jes.2020.09.018.
Lithner D, Larsson Å, Dave G, 2011. Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition. Science of The Total Environment 409, 3309-3324. https://doi.org/10.1016/j.scitotenv.2011.04.038.
Mason SA, Daily J, Aleid G, Ricotta R, Smith M, Donnelly K, et al., 2020. High levels of pelagic plastic pollution within the surface waters of Lakes Erie and Ontario. Journal of Great Lakes Research 46, 277-288. https://doi.org/10.1016/j.jglr.2019.12.012.
Masura J, Baker J, Foster G, Arthur C, 2015. Laboratory Methods for the Analysis of Microplastics in the Marine Environment: Recommendations for quantifying synthetic particles in waters and sediments.

Minor EC, Lin R, Burrows A, Cooney EM, Grosshuesch S, Lafrancois B, 2020. An analysis of microlitter and microplastics from Lake Superior beach sand and surface-water. Science of the Total Environment 744, 140824. https://doi.org/10.1016/j.scitotenv.2020.140824.

Nan B, Su L, Kellar C, Craig NJ, Keough MJ, Pettigrove V, 2020. Identification of microplastics in surface water and Australian freshwater shrimp Paratya australiensis in Victoria, Australia. Environmental Pollution 259, 113865. https://doi.org/10.1016/j.envpol.2019.113865.

Napper IE, Baroth A, Barrett AC, Bhola S, Chowdhury GW, Davies BFR, et al., 2021. The abundance and characteristics of microplastics in surface water in the transboundary Ganges River. Environmental Pollution, 116348. https://doi.org/10.1016/j.envpol.2020.116348.

Ó Briain O, Marques Mendes AR, McCarron S, Healy MG, Morrison L, 2020. The role of wet wipes and sanitary towels as a source of white microplastic fibres in the marine environment. Water Research 182, 116021. https://doi.org/10.1016/j.watres.2020.116021.

Oteef MDY, Elhassan MS, 2020. Plastic toys and child care articles as a source of children exposure to phthalates and other plasticisers in Saudi Arabia. International Journal of Environmental Analytical Chemistry. https://doi.org/10.1080/03067319.2020.1784407.

Pariatamby A, Hamid FS, Bhatti MS, Anuar N, Anuar N, 2020. Status of microplastic pollution in aquatic ecosystem with a case study on cherating river, Malaysia. Journal of Engineering and Technological Sciences 52, 222-241. https://doi.org/10.5614/j.eng.technol.sci.2020.52.2.7.

Peng G, Xu P, Zhu B, Bai M, Li D, 2018. Microplastics in freshwater river sediments in Shanghai, China: A case study of risk assessment in mega-cities. Environmental Pollution 234, 448-456. https://doi.org/10.1016/j.envpol.2017.11.034.

Pico Y, Alfarhan A, Barcelo D, 2019. Nano- and microplastic analysis: Focus on their occurrence in freshwater ecosystems and remediation technologies. TrAC - Trends in Analytical Chemistry 113, 409-425. https://doi.org/10.1016/j.trac.2018.08.022.

Picó Y, Alvarez-Ruiz R, Alfarhan AH, El-Sheikh MA, Alshahrani HO, Barceló D, 2020. Pharmaceuticals, pesticides, personal care products and microplastics contamination assessment of Al-Hassa irrigation network (Saudi Arabia) and its shallow lakes. Science of The Total Environment 701, 135021. https://doi.org/10.1016/j.scitotenv.2019.135021.

Picó Y, Barceló D, 2019. Analysis and prevention of microplastics pollution in water: Current perspectives and future directions. ACS Omega 4, 6709-6719. https://doi.org/10.1021/acsomega.9b00222.

Prata JC, da Costa JP, Lopes I, Duarte AC, Rocha-Santos T, 2020. Environmental exposure to microplastics: An overview on possible human health effects. Science of the Total Environment 702, 134455. https://doi.org/10.1016/j.scitotenv.2019.134455.

Prata JC, Godoy V, da Costa JP, Calero M, Martín-Lara MA, Duarte AC, et al., 2021a. Microplastics and fibers from three areas under different anthropogenic pressures in Douro river. Science of The Total Environment, 145999. https://doi.org/10.1016/j.scitotenv.2021.145999.

Prata JC, Patrício Silva AL, da Costa JP, Mouneyrac C, Walker TR, Duarte AC, et al., 2019. Solutions and integrated strategies for the control and mitigation of plastic

and microplastic pollution. International Journal of Environmental Research and Public Health 16, 2411. https://doi.org/10.3390/ijerph16132411.
Prata JC, Reis V, da Costa JP, Mouneyrac C, Duarte AC, Rocha-Santos T, 2021b. Contamination issues as a challenge in quality control and quality assurance in microplastics analytics. Journal of Hazardous Materials 403, 123660. https://doi.org/10.1016/j.jhazmat.2020.123660.
Rodrigues JP, Duarte AC, Santos-Echeandía J, Rocha-Santos T, 2019. Significance of interactions between microplastics and POPs in the marine environment: A critical overview. TrAC - Trends in Analytical Chemistry 111, 252-260. https://doi.org/10.1016/j.trac.2018.11.038.
Ruiz-Compean P, Ellis J, Cúrdia J, Payumo R, Langner U, Jones B, et al., 2017. Baseline evaluation of sediment contamination in the shallow coastal areas of Saudi Arabian Red Sea. Marine Pollution Bulletin 123, 205-218. https://doi.org/10.1016/j.marpolbul.2017.08.059.
Scherer C, Weber A, Stock F, Vurusic S, Egerci H, Kochleus C, et al., 2020. Comparative assessment of microplastics in water and sediment of a large European river. Science of the Total Environment 738, 139866. https://doi.org/10.1016/j.scitotenv.2020.139866.
Siddiqi ZM, Saleem M, Basheer C, 2016. Surface water quality in a water run-off canal system: A case study in Jubail Industrial City, Kingdom of Saudi Arabia. Heliyon 2, e00128. https://doi.org/10.1016/j.heliyon.2016.e00128.
Tomlinson DL, Wilson JG, Harris CR, Jeffrey DW, 1980. Problems in the assessment of heavy-metal levels in estuaries and the formation of a pollution index. Helgoländer Meeresuntersuchungen 33, 566-575. https://doi.org/10.1007/BF02414780.
Valine AE, Peterson AE, Horn DA, Scully-Engelmeyer KM, Granek EF, 2020. Microplastic Prevalence in 4 Oregon Rivers Along a Rural to Urban Gradient Applying a Cost-Effective Validation Technique. Environmental Toxicology and Chemistry 39, 1590-1598. https://doi.org/10.1002/etc.4755.
Wang G, Lu J, Li W, Ning J, Zhou L, Tong Y, et al., 2021a. Seasonal variation and risk assessment of microplastics in surface water of the Manas River Basin, China. Ecotoxicology and Environmental Safety 208, 111477. https://doi.org/10.1016/j.ecoenv.2020.111477.
Wang S, Zhong Z, Li Z, Wang X, Gu H, Huang W, et al., 2021b. Physiological effects of plastic particles on mussels are mediated by food presence. Journal of Hazardous Materials 404, 124136. https://doi.org/10.1016/j.jhazmat.2020.124136.
Xu P, Peng G, Su L, Gao Y, Gao L, Li D, 2018. Microplastic risk assessment in surface waters: A case study in the Changjiang Estuary, China. Marine Pollution Bulletin 133, 647-654. https://doi.org/10.1016/j.marpolbul.2018.06.020.
Zobkov M, Belkina N, Kovalevski V, Zobkova M, Efremova T, Galakhina N, 2020. Microplastic abundance and accumulation behavior in Lake Onego sediments: A journey from the river mouth to pelagic waters of the large boreal lake. Journal of Environmental Chemical Engineering 8, 104367. https://doi.org/10.1016/j.jece.2020.104367.

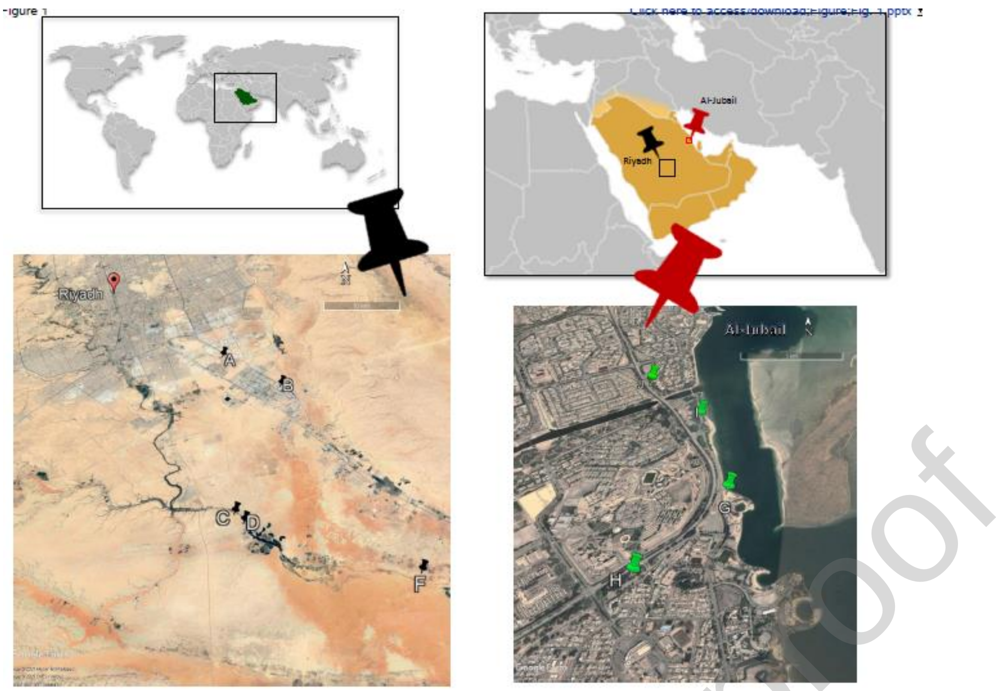


Fig. 1. Maps of the study areas showing the sampling points in Riyadh South (from A to F) and Al-Jubail (from G to J).

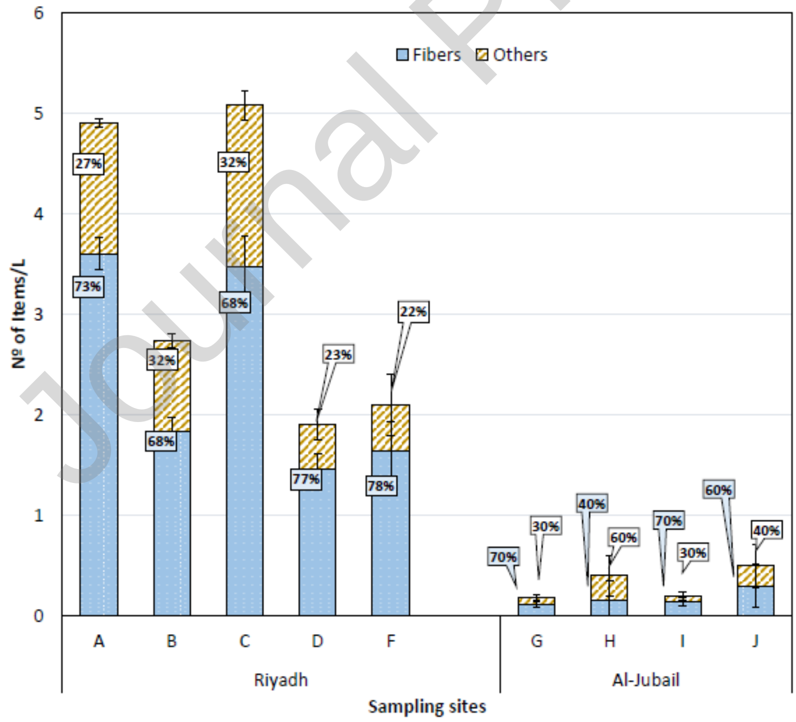


Fig.2. MPs distribution in Riyadh and Al-Jubail

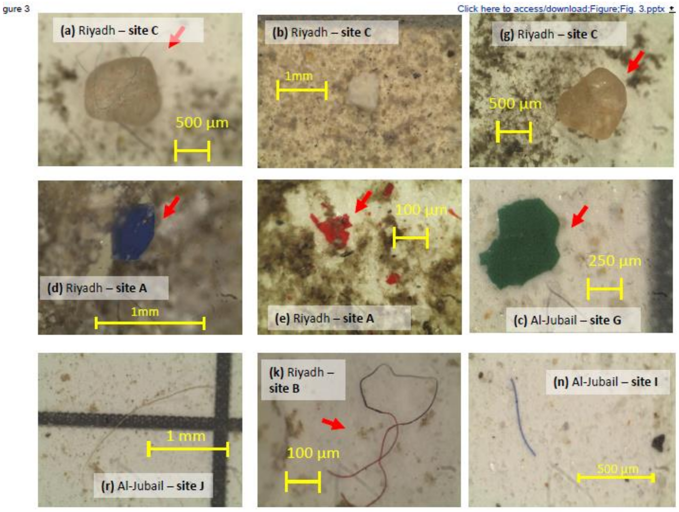


Fig. 3. Photographs of microplastics under the stereomicroscope, sferules (a-c), fragments (d-f) and fibers (g-i).

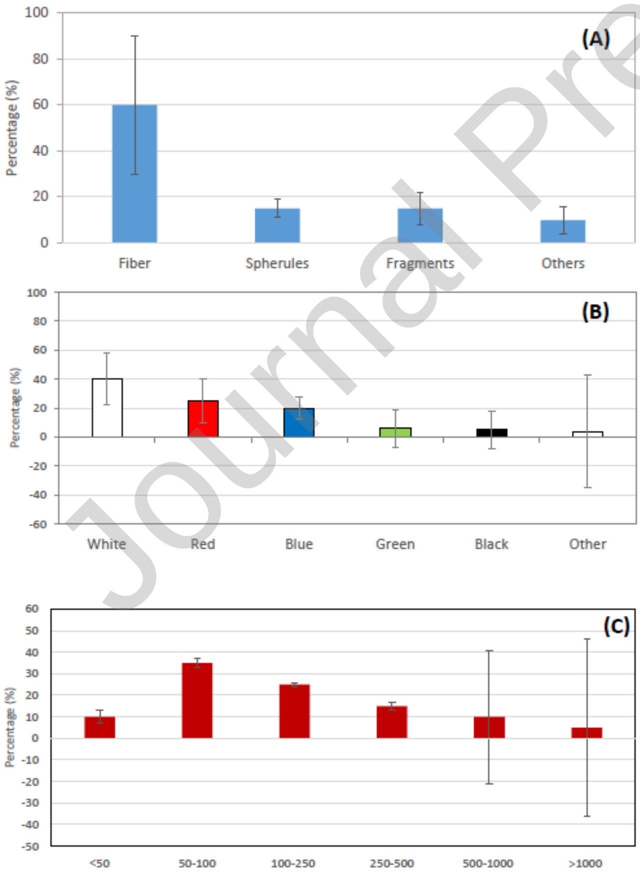


Fig. 4. Shape distribution (a), size distribution (b), color distribution of MPs in surface water samples.

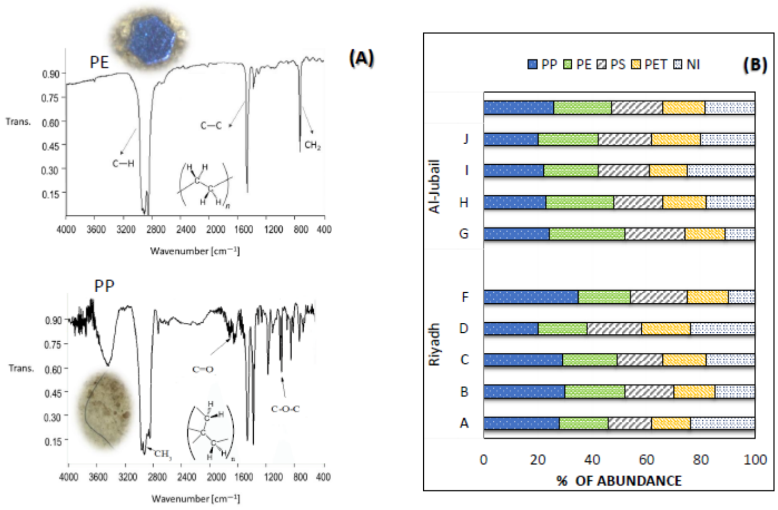


Fig.5. Fourier transform infrared (FTIR) spectra of the selected microplastics (A) spectra of PE (upper part) and PP (lower part) and (B) % of each one of the four types of MPs identified in surface water. Identification of the legend: PE: polyethylene; PP: polypropylene; PS: polystyrene; PET: polyethylene 5erephthalate; NI: not identified.

Figure 6 Click here to access/download;Figure;Fig. 6.pptx

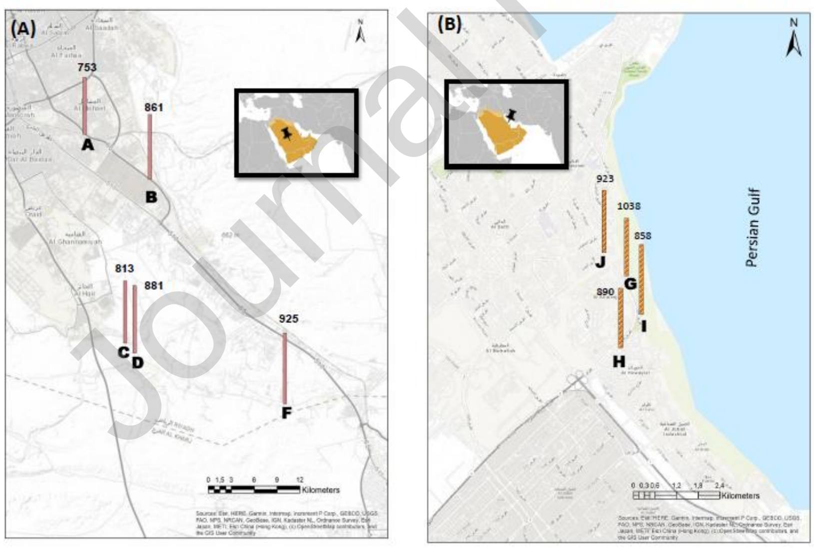


Fig. 6. Hazard index (HI) of MPs in both cities (A) Riyadh and (B) Al-Jubail.

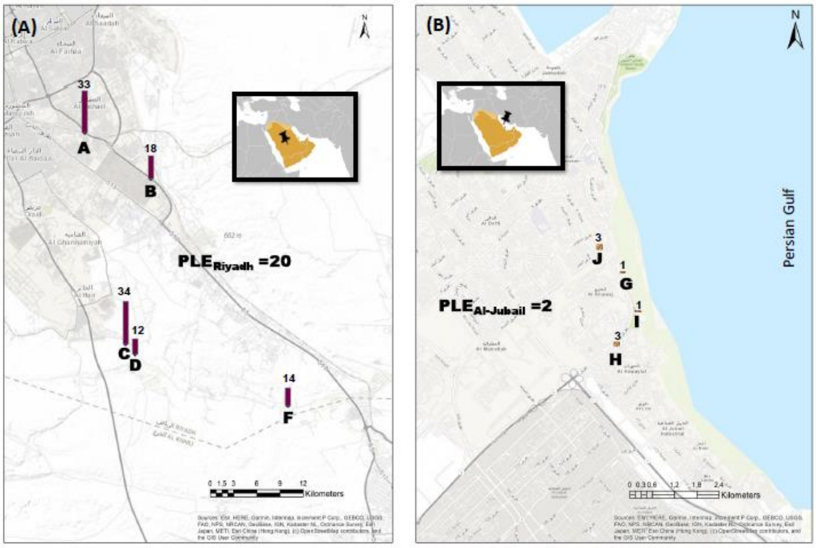


Fig. 7. Pollution load index (PLI) of MPs in both cities (A) Riyadh and (B) Al-Jubail.

Graphical abstract

Credit statement

Yolanda Picó: Methodology, Conceptualization, Resources; Investigation; Writing - Original Draft, Visualization

Vasiliki Soursou: Conceptualization, Methodology, Validation, Formal Analysis; Writing - Review & Editing

Ahmed H. Alfarhan: Writing - Review & Editing, Supervision, Project administration

Mohamed A. El-Sheikh: Methodology, Validation, Resources, Writing - Review & Editing

Damià Barceló: Writing - Review & Editing, Supervision, Project administration, Funding acquisition

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Highlights

- MPs concentration was established using a Turton Town net of 20 µm mesh
- Fibers white or transparent with a size < 250 µm were dominant
- Population and socioeconomic characteristics can influence MPs abundance
- The composition of microplastics by FTIR was identified as PE, PP, PS and PET
- Quantities of MPs and toxicity of their components in water showed ecological risk.