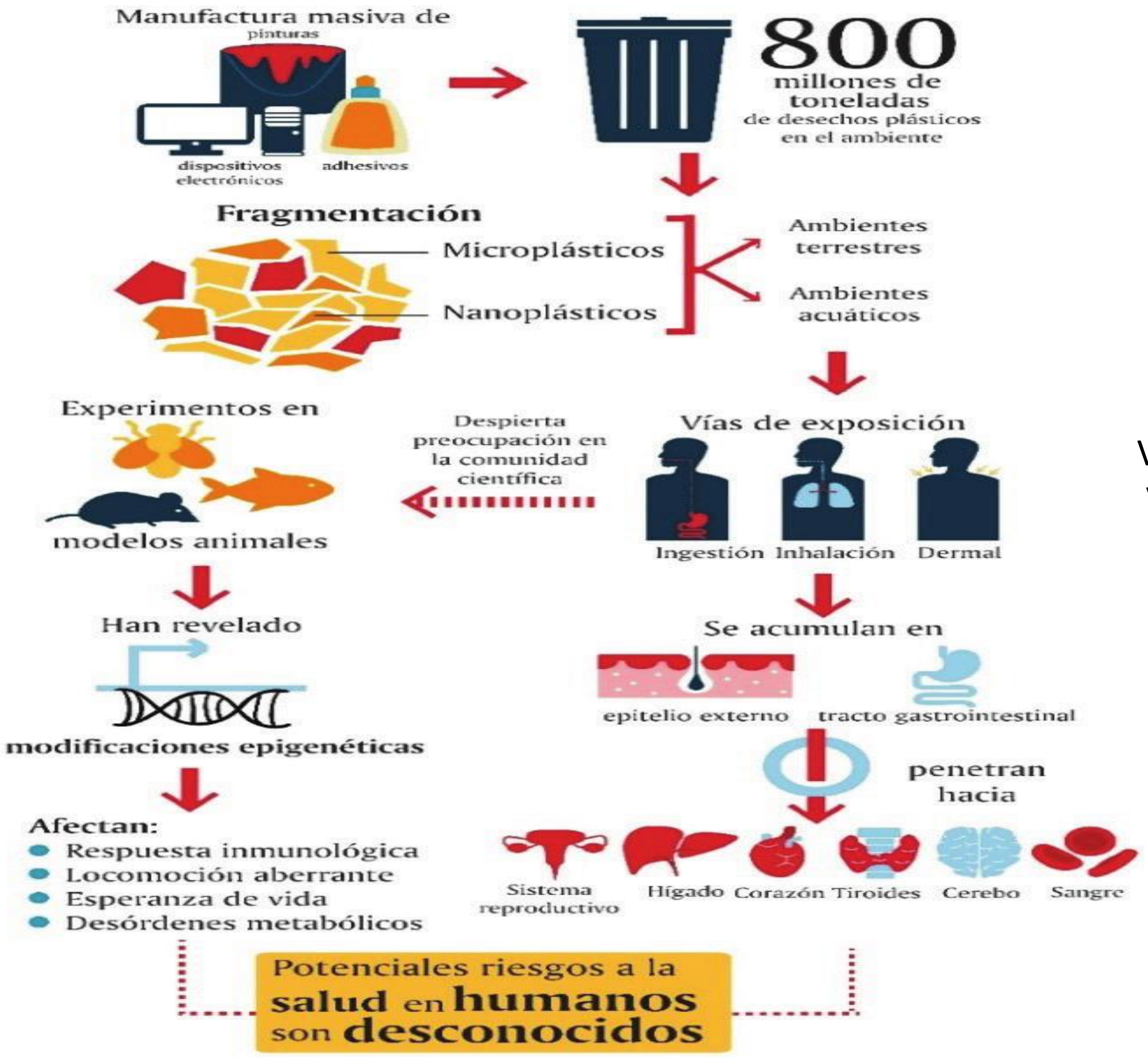
Análisis de Riesgo a la Salud Humana por el consumo de microplásticos y sustancias plastificantes mediante el consumo de especies marinas.

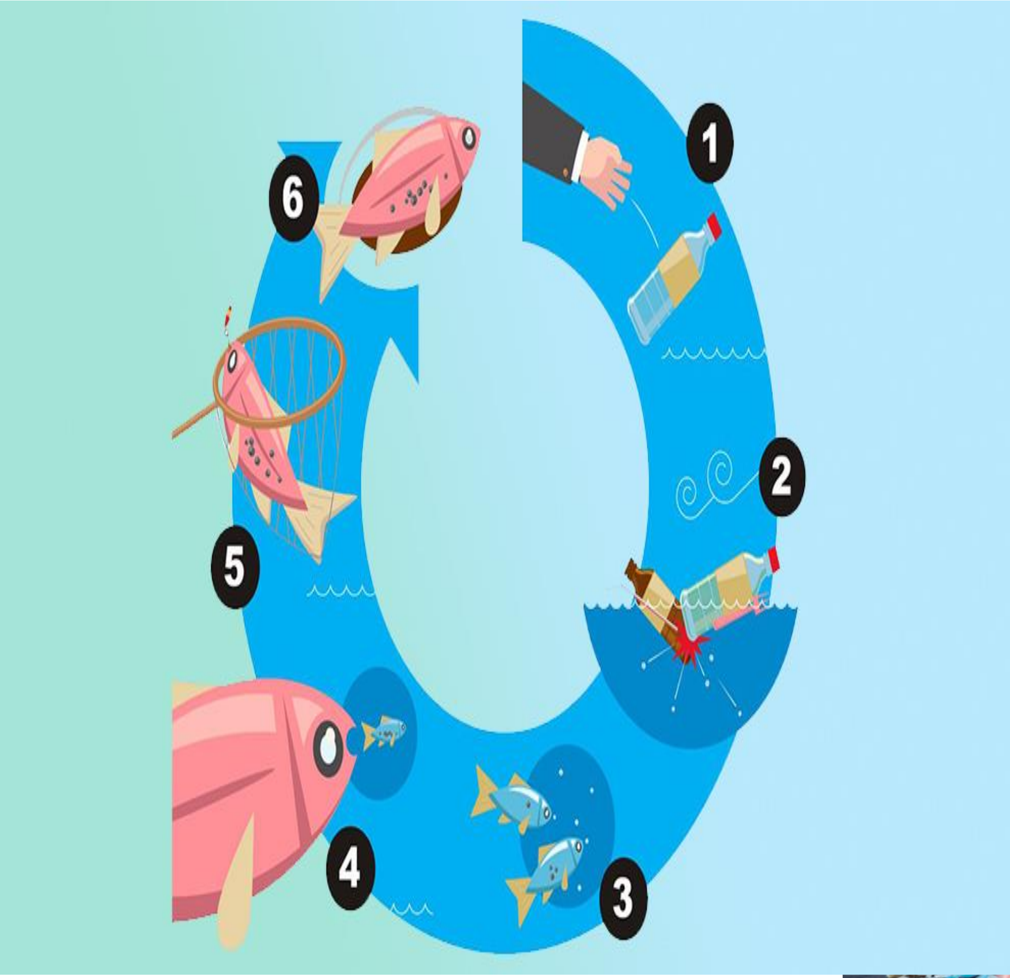
Virginia Montero, Yarenis Chinchilla, Luis Gómez, Adrián Flores, Alejandro Medaglia, Rossy Guillén, Ernesto Montero.

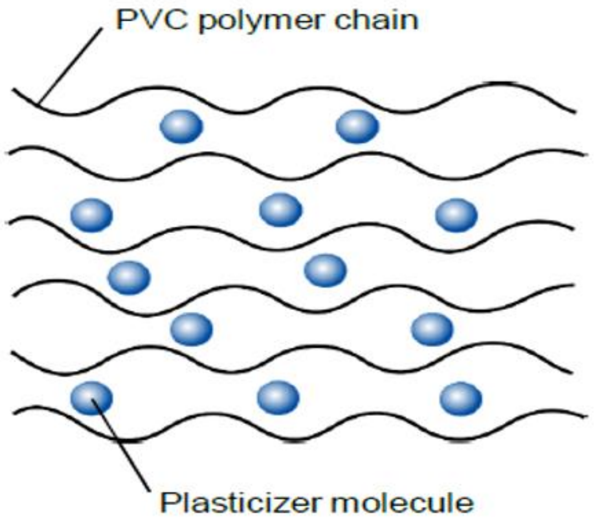
Costa Rica Institute of Technology



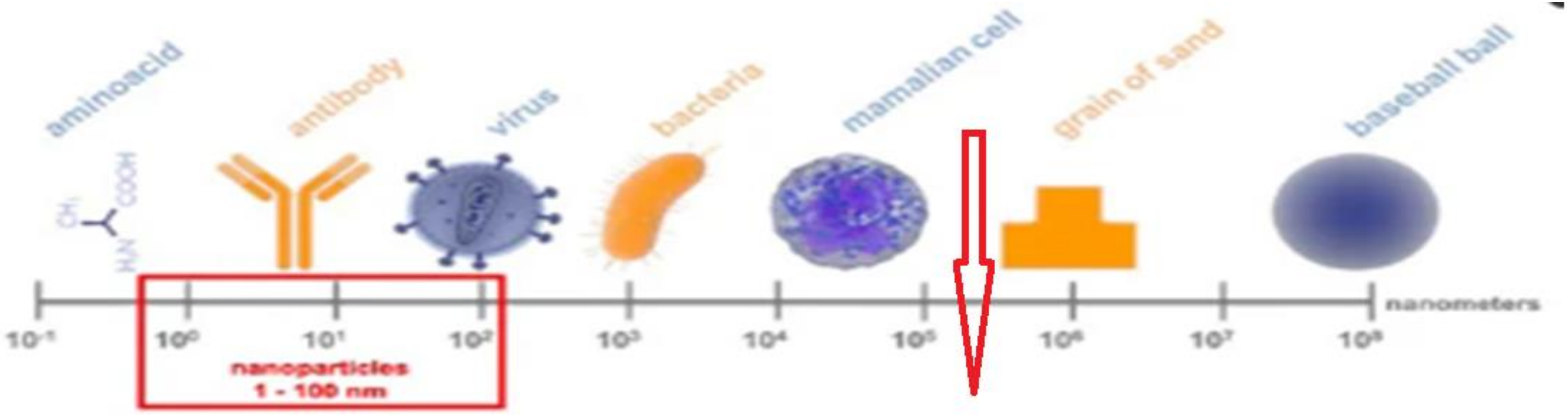
V Montero, et al. 2023 Tec en Marcha
Vol. 36, No 4: 170-180

In the ocean they may act as carriers of additives specific to the plastic materials used in their manufacture, such as plasticizers, among which Bisphenol-A (BPA), bis (2-ethylhexyl) phthalate (DEHP), dybuthyl phthalate (DBP).

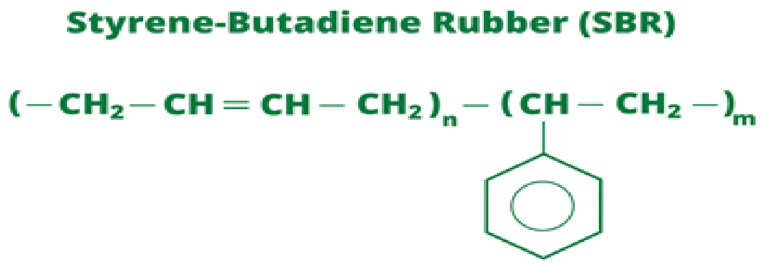




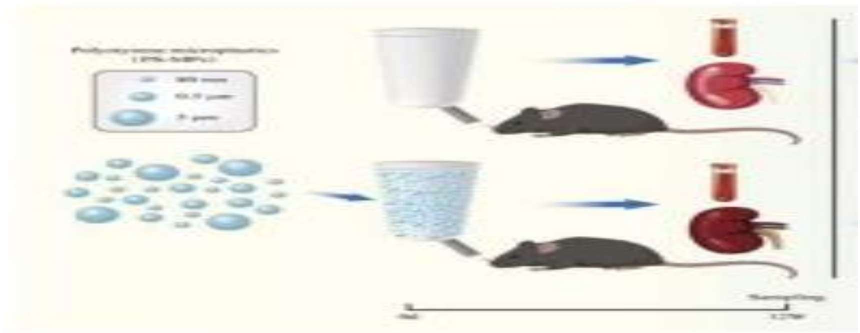
❖Las partículas de plástico, de tamaño inferior a 5 mm, se conocen como microplásticos (MP), no son solubles en agua y su degradabilidad es baja, tardando desde semanas hasta miles de años en descomponerse, dependiendo de las condiciones a las que están expuestas.



- La toxicidad para la salud humana causada por MNP puede deberse a la naturaleza del plástico como tal; tal es el caso del caucho de estireno-butadieno (Gruber et al., 2022); el otro es el tamaño de las partículas (De Felice et al., 2019).



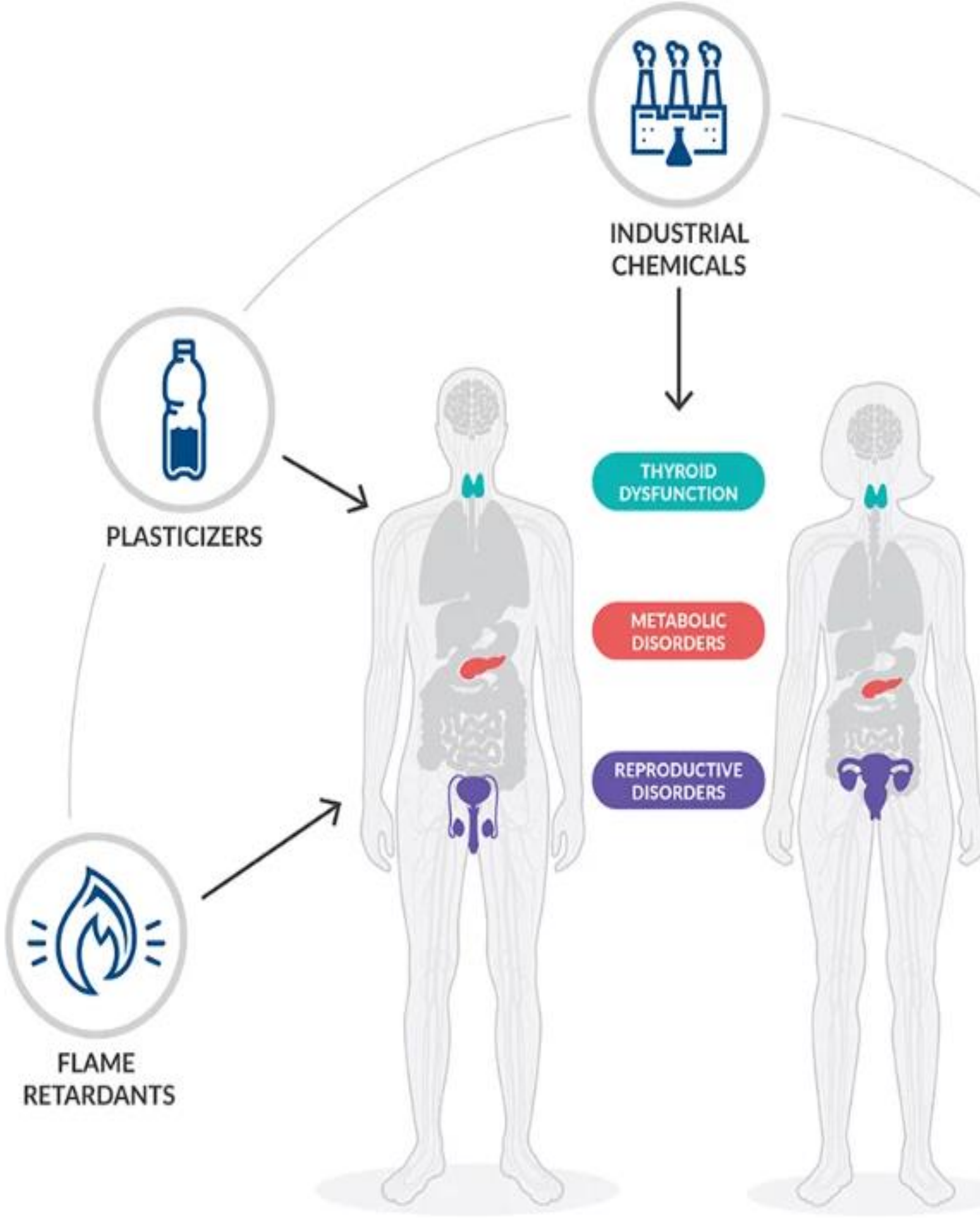
- Cada vez se estudia más el uso de modelos animales con mamíferos para predecir el impacto potencialmente dañino de las MNP en la salud humana; Se ha encontrado que ratones expuestos a MP con diámetros de 5 y 20 µm durante 28 días, mostraron presencia de MP en hígado, riñón e intestino.

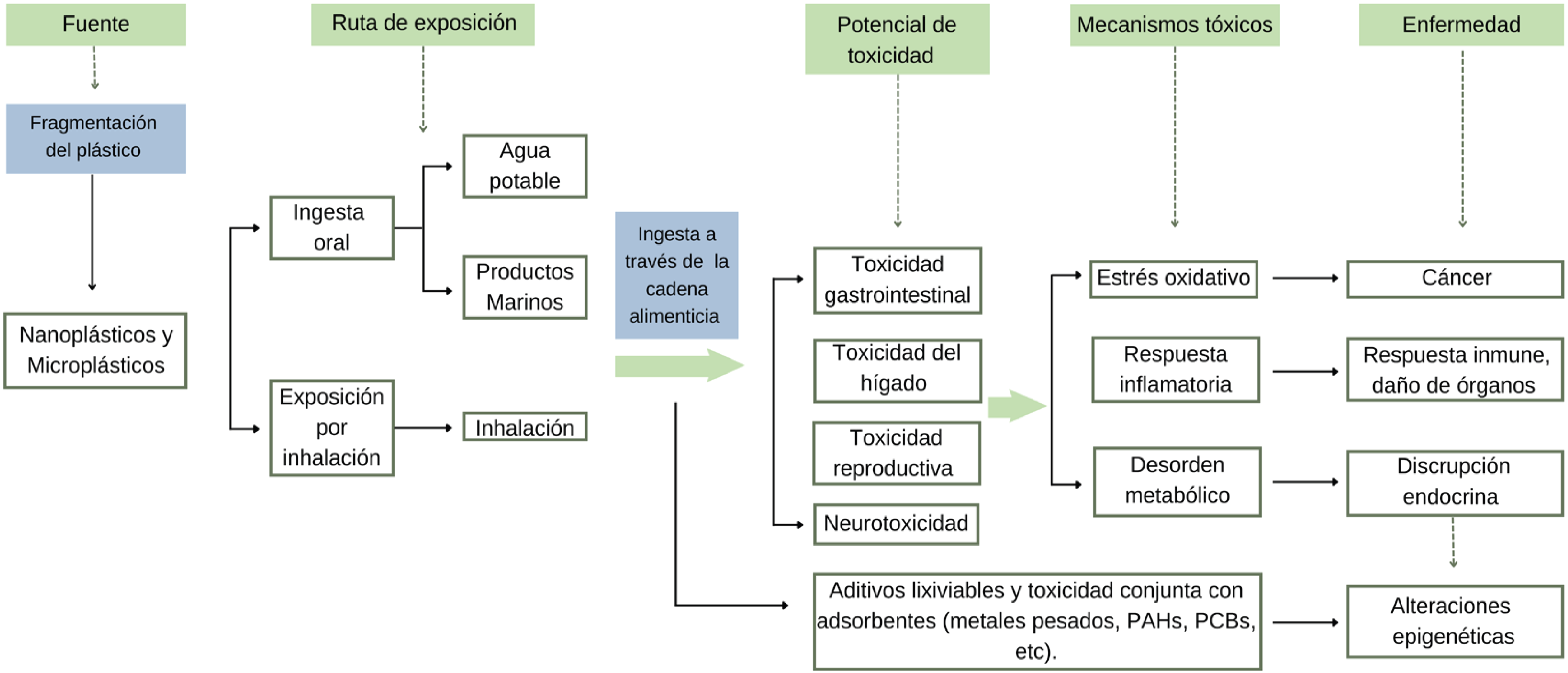


- Estos aditivos plasticospueden tener una variedad de efectos tóxicos:

  - potential carcinogénico
  - Efectos epigenotóxicos
  - El BPA y los ftalatos, entre otros contaminantes ambientales, causan una amplia gama de efectos perjudiciales en el organismo, en parte porque interfieren, en dosis muy bajas, con la función de diversas hormonas; Estos compuestos se conocen como EDC (*productos químicos que alteran el sistema endocrino*).

V Montero, et al. 2023 Tec en Marcha. Vol. 36, No 4: 170-180.





V Montero, et al. 2023 Tec en Marcha. Vol. 36, No 4: 170-180.

- En la presente investigación se realizó el aislamiento de MP y la cuantificación de sustancias plastificantes en las mismas muestras de especies marinas: mangrove cockle (piangua) (*Anadara tuberculosa*), Stolzmann’s weakfish (corvina) (*Cynoscion stolzmanni*) y arched swimming crab (cangrejo) (*Callinectes arcuatus*).

Stolzmann’s weakfish

Arched swimming crab

Mangrove cockle

- Finalmente, se realizó una evaluación de riesgo y se calculó la exposición dietética al BPA a la que estarían expuestos los consumidores con estos alimentos. Estos valores se compararon con la dosis de ingesta tolerable (TDI) establecida por la Autoridad Europea de Seguridad Alimentaria (EFSA).

Materiales and Métodos

Extracción, cuantificación y visualización de MP.

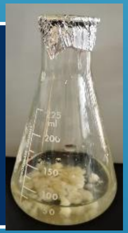
- Las especies marinas fueron recolectadas directamente de pescadores del Golfo de Nicoya, Costa Rica durante el año 2020. Se trabajó con 86 ejemplares de muestras compuestas, (estas muestras también se utilizaron para la determinación de sustancias plastificantes).

- La extracción de MP se realizó mediante técnicas físico-químicas y la identificación se realizó empleando las técnicas de microscopía óptica, espectrómetro de energía dispersiva (EDS), microscopio electrónico de barrido (SEM) y espectroscopia Raman.

Pesaje

50 ml H_2O tipo I

6 ml H_2O_2 al 45%



OXI 18 horas agitación 107 rpm

6 ml KOH al 9%

OXI 2 horas agitación 107 rpm

Sonicar 10 min

Filtración tamiz acero 106 um en cristalizador

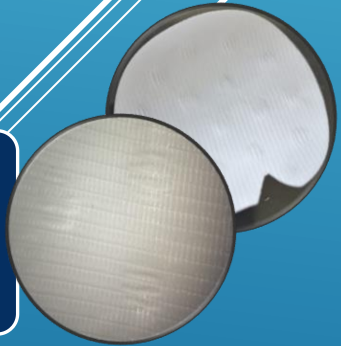
Enjuague matraz 100 ml H_2O tipo I y trasvase

Enjuague cristalizador 50 ml agua tipo I

Calentamiento baño térmico 15 min 60°C

Filtración al vacío membrana politetrafluoroetileno 0,5 um

Secado filtros en desecador silica gel



AISLAMIENTO DE MICROPLÁSTICOS DE ESPECIES MARINAS. Por Yarenis Chinchilla Ballestero.

Cuantificación de BPA y Pthalates (DEHP and DBP).

- La identificación y cuantificación se realizó mediante un equipo de cromatografía de gases masas (GC-MS con sistema de inyección (Thermo Scientific Trace 1310) con detector de espectrometría de masas, triple cuadrupolo.

Análisis de riesgo toxicológico asociado al consumo de arched swimming crab, mangrove cockle y Stolzmann's weakfish.

Exposición Dietaria:

Data needed:

- Data on substance concentration (µg substance/g food)
- Data on food consumption (g food/day)
- Body weight *BW* (kg)

These values are compared to TDI established for each case by recommendation of EFSA (European Foods Safety Authority).

Calculation:

$$Dietary\ Exposure = \frac{Food\ consumption \times Substance\ concentration}{Body\ weight}$$

Results

Cantidad de MP encontradas:

- Para esta investigación se trabajó con tamices que permitieron el paso de partículas cuyo tamaño osciló entre 0.5 µm - 106 µm, obteniendo así los siguientes resultados promedio: para Arched swimming crab 4.0 ± 1.0 (SD) MP/g; en el caso mangrove cockle el valor correspondió a 3,3 ± 2,9 (SD) MP/g; en el caso de Stolzmann's weakfish se obtuvo una media de 2,4 ± 1,3 (DE) MP/g.

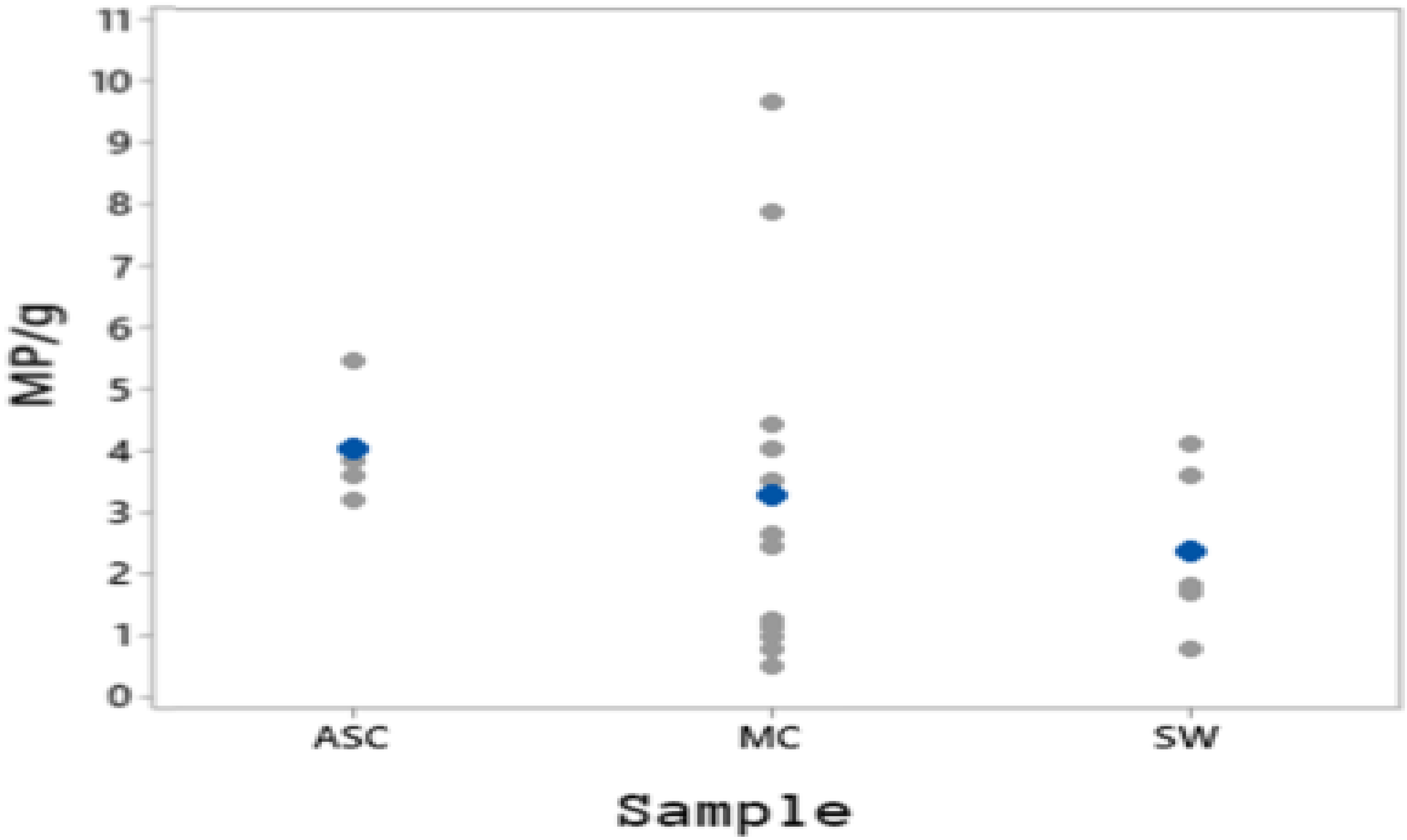


Fig 1 Amount of MP in composite samples; ASC: arched swimming crab, MC: mangrove cockle, SW: Stolzmann's weakfish. The blue points represent the average value of each marine species.

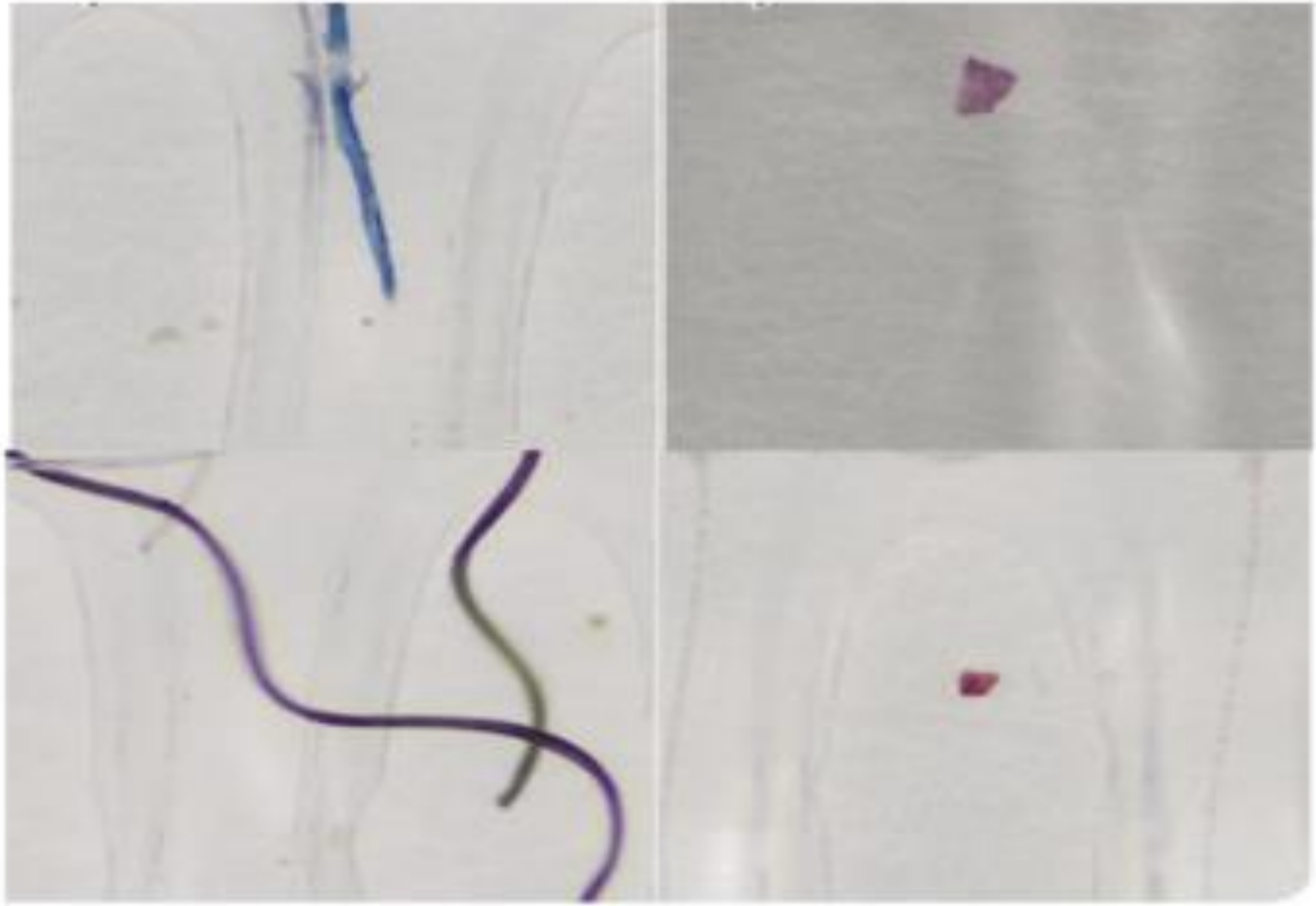


Fig 2. Pictures of isolated MP from marine species seen on the optical microscope at 4x; the different colors are shown.

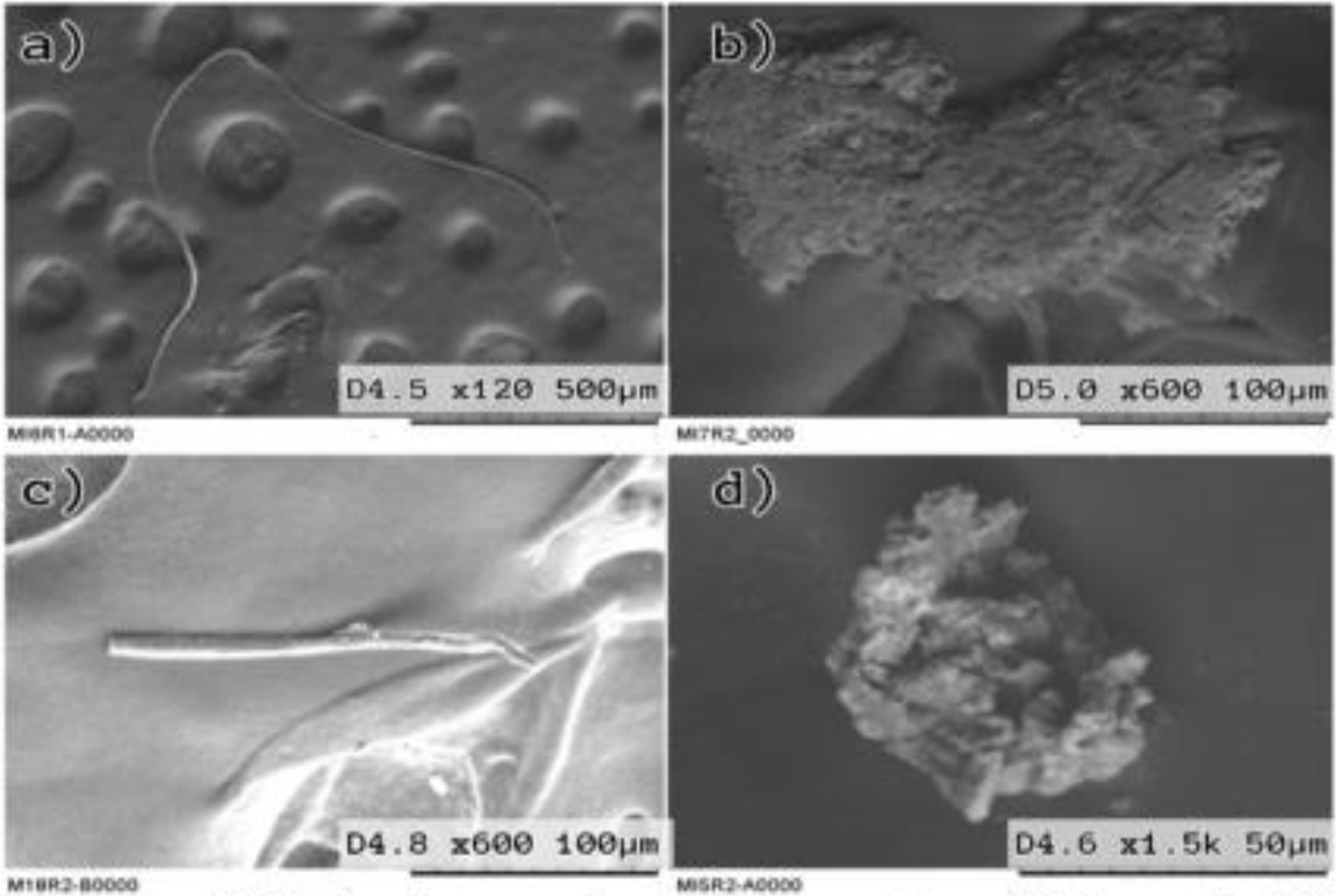


Fig 4. Micrographs of MP found on samples of Stolzmann's weakfish: a and c) fibers; b and d) particles.

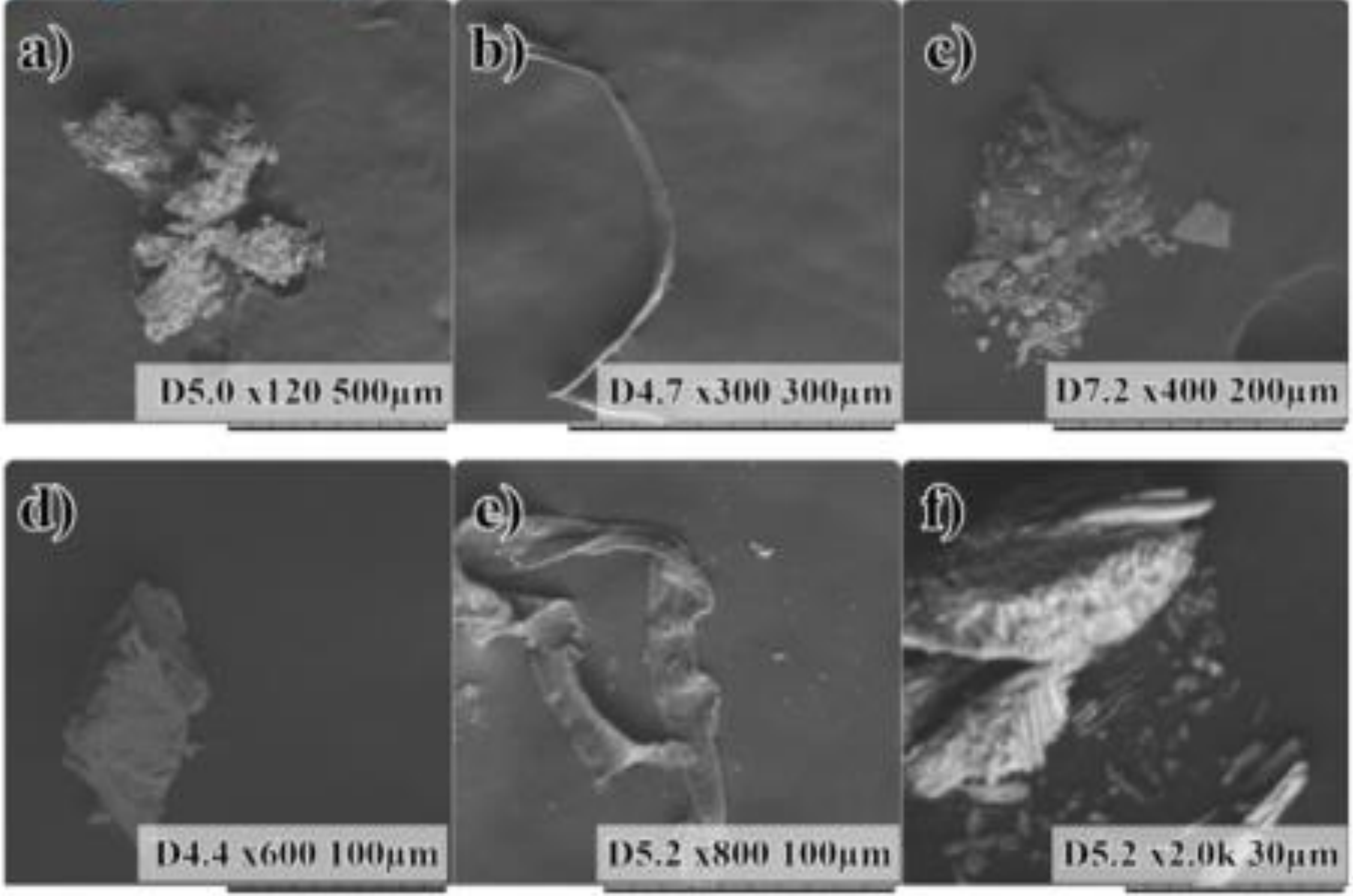


Fig 3. Micrographs of MP found on samples of mangrove cockle. a, c, d, f particles; b, e fibers.

Table 1. MP characterization by SEM/EDS and Raman of identified marine species.

Species	SEM/EDS	Wavelength (cm^{-1}) Raman peaks	Reference (Rebollar et al., 2014)	Possible identification
Arched swimming crab	Ideal EDS	1720 1611 1287	C=O C-C benzene ring C-O	PET
Mangrove cockle	Ideal EDS	1572 1311	ND C-H	PA or PE
Mangrove cockle	Ideal EDS	1611 1486	C-C C-H, C-OH	PA
Mangrove cockle	EDS with 7.7% Al.	1720 1605 1281	C=O C-C benzene ring C-O	PET
Mangrove cockle	Ideal EDS	605 435	ND ND	ND
Mangrove cockle	EDS with 5.6% Ca.	1076 639	C-C C-Cl	PVC
Mangrove cockle	Ideal EDS	1568 534	ND ND	ND
Stolzmann's weakfish	Ideal EDS	1590 1315	N-H C-H	PA
Stolzmann's weakfish	Ideal EDS	1723 1609 1283 853	C=O C-C benzene ring C-O C-H	PET
Stolzmann's weakfish	Ideal EDS	1533 1332 739	C-O-C C-H ND	ND

*ND: Not defined

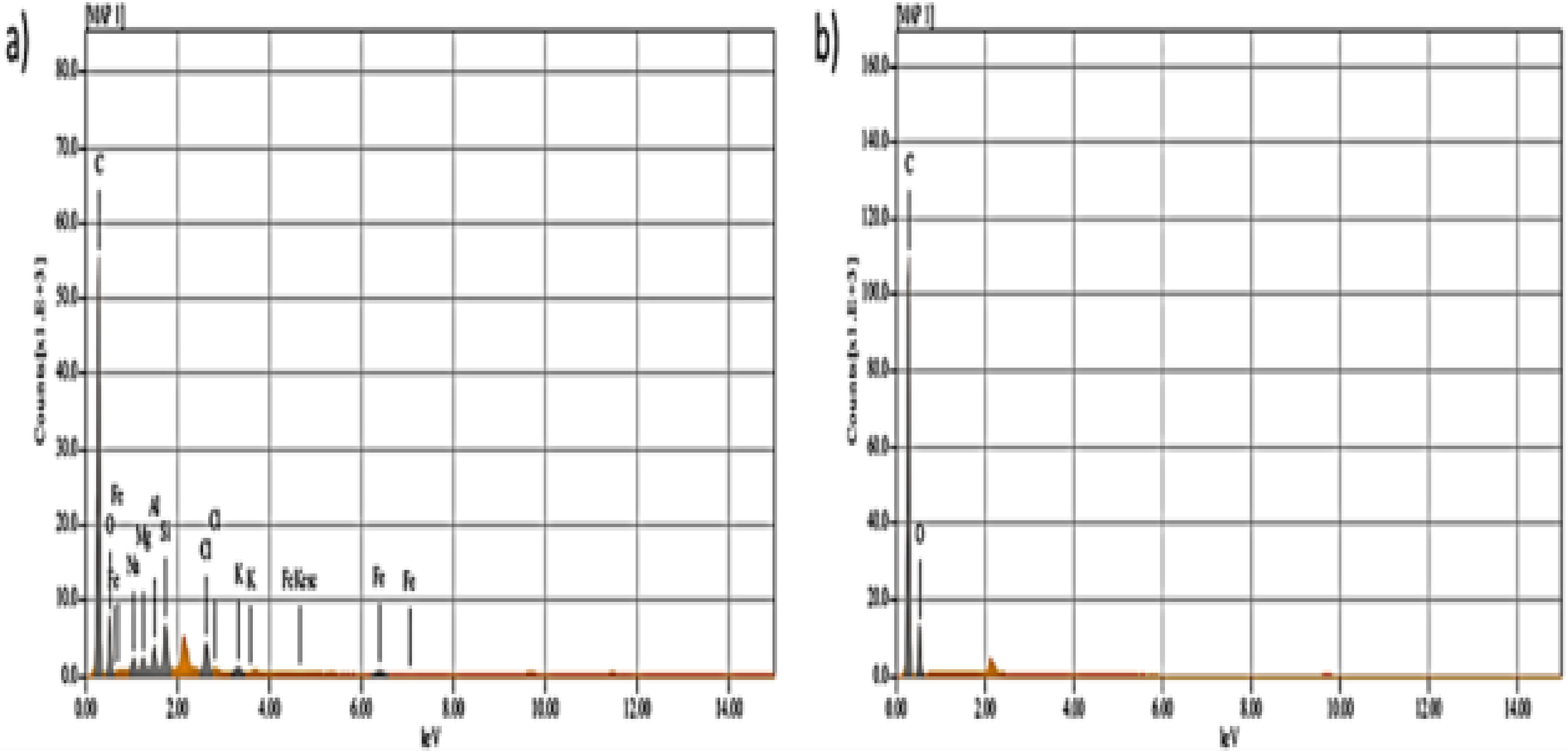


Fig 5. Graphs of EDS samples from MPs corresponding to a) polyethylene and b) polypropylene found in arched swimming crabs.

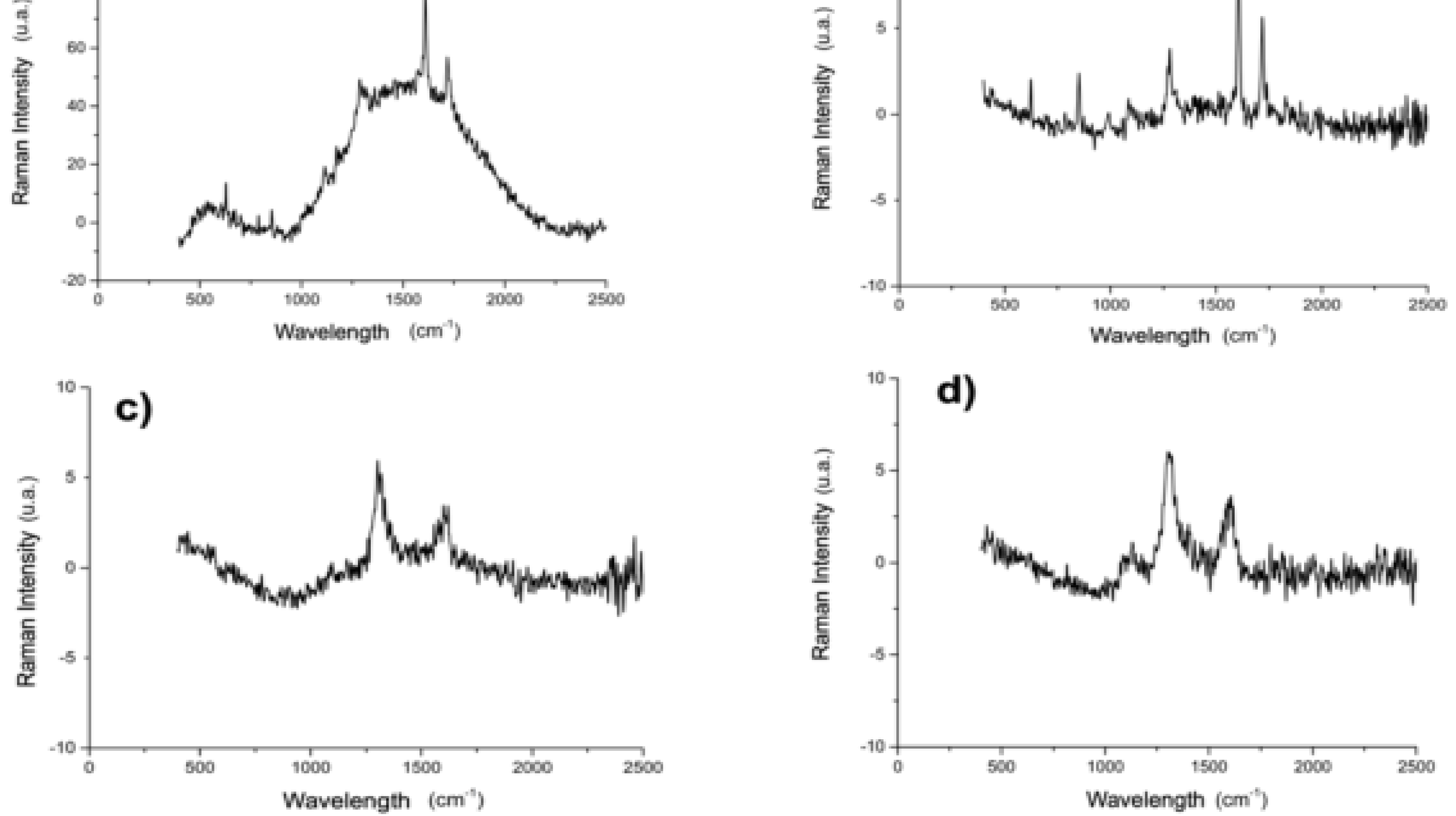


Fig 6. Raman spectra of MP, corresponding to MP found in marine species, a) arched swimming crab, b) mangrove cockle, c) and d) Stolzmann's weakfish. 780nm Laser and 3mW power.

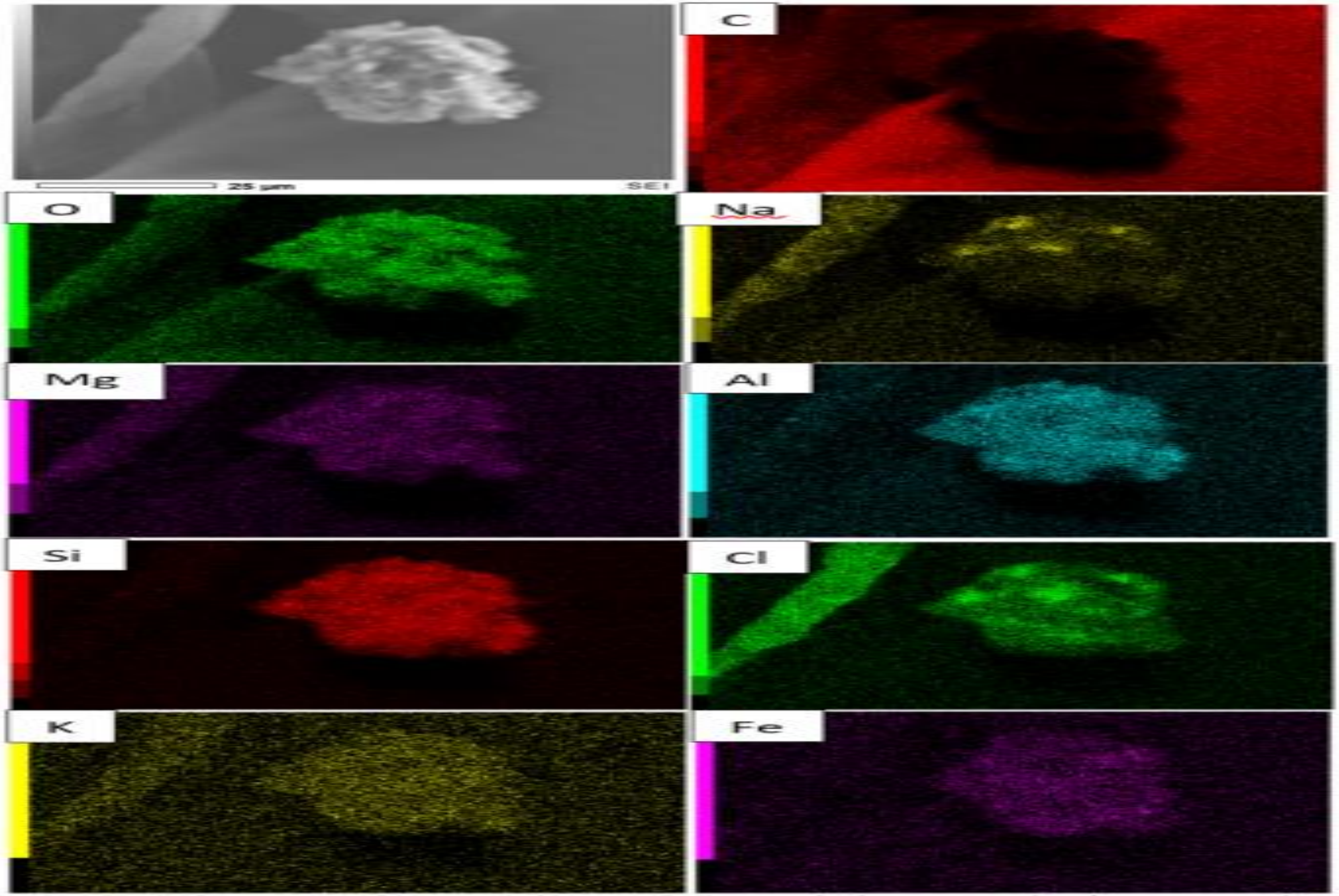


Fig 7. Elemental mapping of a particle correlating to microplasti

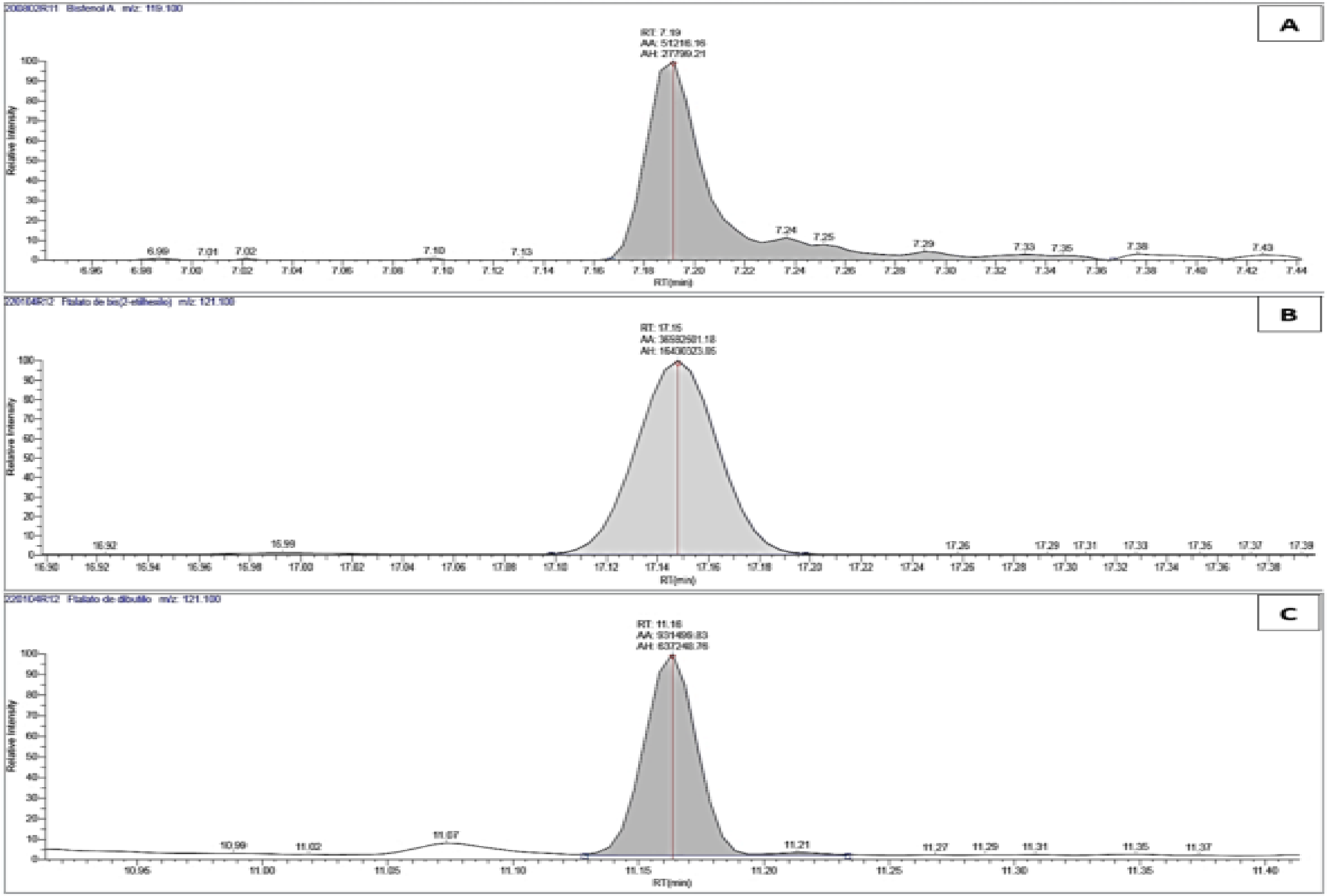


Fig 8. A: corresponds to a detected BPA signal in a sample of arched swimming crab; the signal is triggered in 7.19 minutes; B: corresponds to a DEHP signal in a sample of mangrove cockle; signal is triggered in 17.15 minutes and C: corresponds to a DBP signal in mangrove cockle; the signal is triggered in 11.16 minutes.

Table 2. Plasticizers found in positive composite samples for marine species.

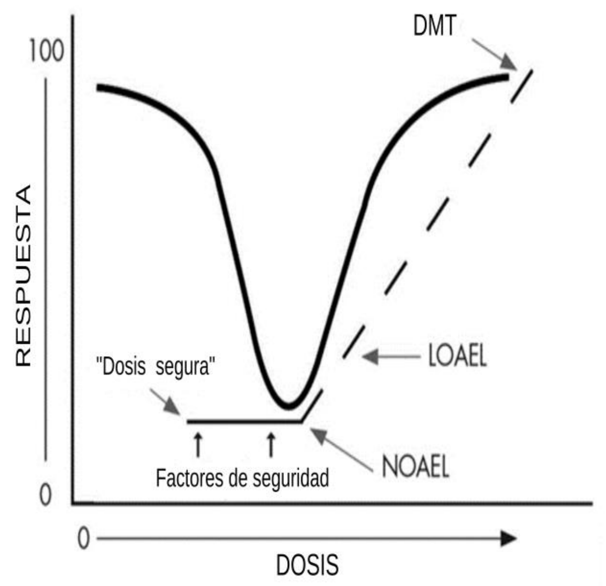
Marine species	Composite samples	Analytes	Average concentration (µg /g sample) *	Range of concentrations (µg /g)
Mangrove cockle	15	BPA	0.014 ± 0.006	0.008 - 0.039
Mangrove cockle	15	DEHP	0.13 ± 0.01	0.01 – 1.41
Mangrove cockle	7	DBP	0.017 ± 0.002	0.013 – 0.025
Arched swimming crab	5	BPA	0.028 ± 0.006	0.007 – 0.076
Arched swimming crab	5	DEHP	0.03 ± 0.01	0.01 – 0.1
Arched swimming crab	1	DBP	0.059 ± 0.002	0.059 – 0.059
Stolzmann's weakfish	7	BPA	0.009 ± 0.006	0.006 – 0.018
Stolzmann's weakfish	12	DEHP	0.04 ± 0.01	0.01 – 0.08
Stolzmann's weakfish	8	DBP	0.019 ± 0.002	0.013 – 0.022

* LD: 0,002 µg/g, LC: 0.006 µg/g for BPA & DEHP and 0.008 µg/g for DBP

Table 3. Dietary exposure and TDI relation for adults according to values obtained in the study.

Species	Analytes	Average concentration (µg/kg sample)	Dietary exposure (D. exp) per portion µg/kg/ bw/d	TDI food (EFSA, 2015) µg/kg/ bw/d	Relationship D.exp -TDI a Pregnant women	TDI n b (New value proposed EFSA) 2021
Mangrove cockle	BPA	14	0.015	4	D.exp < TDI	**D.exp >>TDI**
Mangrove cockle	DEHP	130	0.139	50	N.D c	N.D
Mangrove cockle	DBP	17	0.018	10	N.D	N.D
Stolzmann's weakfish	BPA	9	0.023	4	D.exp < TDI	**D.exp >>TDI**
Stolzmann's weakfish	DEHP	40	0.10	50	N.D	N.D
Stolzmann's weakfish	DBP	19	0.049	10	N.D	N.D

a TDI pregnant women for BPA 0.33 µg/kg/bw/d (ANSES, 2014)
b TDI n New value proposed 0.004 ng/ kg bw/d of BPA (European Food Safety Authority, 2021) for EDCs damages.
c N.D: No updated data available (EFSA Panel on Food Contact Materials, Enzymes and Processing Aids (CEP) et al., 2022).



Environmental Research 237 (2023) 116843

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Human health risk assessment for consumption of microplastics and plasticizing substances through marine species

Virginia Montero [a,c,*], Yarenis Chinchilla [a,c], Luis Gómez [b], Adrián Flores [b], Alejandro Medaglia [a,c], Rossy Guillén [a,c], Ernesto Montero [d]

[a] Biotechnology Research Center. School of Biology, Costa Rica Institute of Technology, Cartago, 30101, Cartago, Costa Rica
[b] CEQIATEC Research Center. School of Chemistry, Costa Rica Institute of Technology, Cartago, 30101, Cartago, Costa Rica
[c] Institutional Microscopy Laboratory. Costa Rica Institute of Technology, Cartago, 30101, Cartago, Costa Rica
[d] Laboratory of Molecular Spectroscopy, Images and Color. School of Physics, Costa Rica Institute of Technology, Cartago, 30101, Cartago, Costa Rica

ARTICLE INFO

Handling editor: Jose L Domingo

Keywords:
Bisphenol-A (BPA)
Bis (2-ethylhexyl) phthalate (DEHP)
Dybuthyl phthalate (DBP)
Microplastics
Scanning electron microscopy
Dietary exposure

ABSTRACT

A special characteristic of MP (microplastics) in the ocean is they may act as carriers of additives specific to the plastic materials used in their manufacture, such as plasticizers, among which Bisphenol-A (BPA), bis (2-ethylhexyl) phthalate (DEHP), dybuthyl phthalate (DBP). Both MP as the plasticizers were searched in composite samples of mangrove cockle (*Anadara tuberculosa*), Stolzmann's weakfish (*Cynoscion stolzmanni*) and arched swimming crab (*Callinectes arcuatus*). Extraction of MP was done through physical-chemical techniques and identification was carried out employing the techniques of light microscopy, energy dispersive spectrometer (EDS), scanning electron microscope (SEM) and Raman spectroscopy; the sizes of MP obtained were between 0.5 µm and 106 µm, the following average results being obtained: for Arched swimming crab 4.0 ± 1.0 MP/g; mangrove cockle 3.3 ± 2.9 MP/g; and for Stolzmann's weakfish, the average was 2.4 ± 1.3 MP/g; the most observed shapes were fibers and irregular segments; the most identified MP was polyethylene terephthalate (PET). Regarding extraction and quantification of plasticizers, the extraction stage was carried out using QuEChERS tubes; and the identification and quantification with gas chromatography coupled to a mass spectrometer (GC-MS). Regarding the plasticizing substances, DEHP was found in detectable levels in all the samples; BPA was found in 84% of the composite samples analyzed; DBP was found in 50% of them, of the analyzed samples 34% were positive for the 3 analytes. The dietary exposure of people to plasticizers was calculated and for BPA the exposure obtained was compared with respect to the TDI (tolerable intake dose) for pregnant women and the new TDI proposed by EFSA in 2021 according to the estrogenic effect of this substance in the fetus. The objective of the work was to determine if a relationship could be established between both PM and plasticizers, which gave a positive relationship.

Conclusiones

- De acuerdo a los datos obtenidos se puede afirmar que de los plastificantes encontrados, si bien no se puede afirmar que provengan exclusivamente de residuos plásticos encontrados como (MP), no se puede descartar su procedencia; ya que el trabajo consistió en determinar micropartículas y sustancias plastificantes en las mismas muestras, dichas muestras fueron adquiridas directamente de los pescadores artesanales.

- Sin duda si se puede afirmar que los plastificantes, sustancias peligrosas y especialmente importantes como el BPA, DEHP y DBP, han alcanzado los niveles más altos de la cadena trófica, cabe expresar que el 34% de las muestras fueron positivas para los 3 plastificantes, lo que sugiere un efecto de mezcla tóxica, de forma sinérgica; se deben establecer medidas urgentes para proteger el recurso marino de la contaminación por plásticos, y por ende, la salud pública.

- Si bien es cierto que los plastificantes tienen una distribución global ubicua, cobra especial importancia el riesgo que supone la presencia de estas sustancias en alimentos o agua de consumo humano, siendo especialmente sensibles los niños y las mujeres embarazadas. Se pueden realizar otros estudios, especialmente prospectivos, para establecer dosis seguras de estas sustancias en estas poblaciones vulnerables.
- De acuerdo al tipo de sustancia encontrada, se sugiere a las mujeres embarazadas no ingerir mariscos durante el periodo de gestación, considerando la baja cantidad sugerida de BPAs en alimentos, estando actualmente bajo el criterio científico de EFSA; bajo aceptación por TDI de 0.004 ng/kg pc d; dado el efecto estrogénico de esta sustancia en el periodo de gestación del feto y también se debe limitar su consumo por parte de los niños.

References

Adeyi, A. A., & Babalola, B. A. (2019). Bisphenol-A (BPA) in Foods commonly consumed in Southwest Nigeria and its Human Health Risk. *Scientific Reports*, *9*(1). https://doi.org/10.1038/s41598-019-53790-2

ANSES. (2014). *Opinion of the French Agency for Food, Environmental and Occupational Health & Safety in response to the consultation of the European Food Safety Authority on its draft Opinion regarding the assessment of risks to human health related to dietary exposure to Bisphenol A*.

Barwick, V. (2016). *EURACHEM / CITAC Guide Guide to Quality in Analytical Chemistry An Aid to Accreditation Third edition.*

Carli, F., Tait, S., Busani, L., Ciociaro, D., Della Latta, V., Pala, A. P., Deodati, A., Raffaelli, A., Pratesi, F., Conte, R., Maranghi, F., Tassinari, R., Fabbrizi, E., Toffol, G., Cianfarani, S., La Rocca, C., & Gastaldelli, A. (2022). Exposure to Endocrine Disruptors (Di(2-Ethylhexyl)phthalate (DEHP) and Bisphenol A (BPA)) in Women from Different Residing Areas in Italy: Data from the LIFE PERSUADED Project. International Journal of Molecular Sciences, 23(24). https://doi.org/10.3390/ijms232416012

Chang, X., Xue, Y., Li, J., Zou, L., & Tang, M. (2020). Potential health impact of environmental micro- and nanoplastics pollution. In *Journal of Applied Toxicology* (Vol. 40, Issue 1, pp. 4–15). John Wiley and Sons Ltd. https://doi.org/10.1002/jat.3915

Chang, W. H., Chou, W. C., Waits, A., Liao, K. W., Kuo, P. L., & Huang, P. C. (2021). Cumulative risk assessment of phthalates exposure for recurrent pregnancy loss in reproductive-aged women population using multiple hazard indices approaches. Environment International, 154. https://doi.org/10.1016/j.envint.2021.106657

De Felice, B., Sabatini, V., Antenucci, S., Gattoni, G., Santo, N., Bacchetta, R., Ortenzi, M. A., & Parolini, M. (2019). Polystyrene microplastics ingestion induced behavioral effects to the cladoceran *Daphnia magna*. *Chemosphere*, *231*, 423–431. https://doi.org/10.1016/j.chemosphere.2019.05.115

De Ruijter, V. N., Redondo-Hasselerharm, P. E., Gouin, T., & Koelmans, A. A. (2020). Quality Criteria for Microplastic Effect Studies in the Context of Risk Assessment: A Critical Review. *Environmental Science and Technology*, *54*(19), 11692–11705. https://doi.org/10.1021/acs.est.0c03057

Erkekoğlu, P. (2022). Bisphenols (Vol. 1). BoD - Books on Demand.

European Food Safety Authority. (2015). Scientific Opinion on the risks to public health related to the presence of bisphenol A (BPA) in foodstuffs. *EFSA Journal*, *13*(1). https://doi.org/10.2903/j.efsa.2015.3978

European Food Safety Authority Panel on Contaminants in The Food Chain (CONTAM). (2016). Presence of microplastics and nanoplastics in food, with particular focus on seafood. *EFSA Journal*, *14*(6). https://doi.org/10.2903/j.efsa.2016.4501

European Food Safety Authority. (2021). *Bisphenol A: EFSA draft opinion proposes lowering the tolerable daily intake.*

European Food Safety Authority Panel on Food Contact Materials, Enzymes and Processing Aids (CEP), Lambré, C., Barat Baviera, J. M., Bolognesi, C., Chesson, A., Cocconcelli, P. S., Crebelli, R., Gott, D. M., Grob, K., Lampi, E., Mengelers, M., Mortensen, A., Rivière, G., Steffensen, I. L., Tlustos, C., Van Loveren, H., Vernis, L., Zorn, H., Ahrens, B., Fabjan, E., Nicolas, R., Polci, L., Baert, K., Volk, K., & Castle, L. (2022). Identification and prioritisation for risk assessment of phthalates, structurally similar substances and replacement substances potentially used as plasticisers in materials and articles intended to come into contact with food. *EFSA Journal*, *20*(5). https://doi.org/10.2903/j.efsa.2022.7231

Fabara De la Paz, E. A. (2020). *Propuesta de un protocolo para la extracción e identificación de la presencia de microplásticos en Lycopersicon esculentum var. cerasiforme (tomate cherry) convencional y orgánico comercializados en la ciudad de Quito, Ecuador*. Universidad Central del Ecuador.

Facchetti, S. V., La Spina, R., Fumagalli, F., Riccardi, N., Gilliland, D., & Ponti, J. (2020). Detection of metal-doped fluorescent pvc microplastics in freshwater mussels. *Nanomaterials*, *10*(12), 1–14. https://doi.org/10.3390/nano10122363

Gruber, E. S., Stadlbauer, V., Pichler, V., Resch-Fauster, K., Todorovic, A., Meisel, T. C., Trawoeger, S., Hollóczki, O., Turner, S. D., Wadsak, W., Vethaak, A. D., & Kenner, L. (2022). To Waste or Not to Waste: Questioning Potential Health Risks of Micro- and Nanoplastics with a Focus on Their Ingestion and Potential Carcinogenicity. In *Exposure and Health*. Springer Science and Business Media B.V. https://doi.org/10.1007/s12403-022-00470-8

Kim, J. A., Kim, M. J., Song, J. A., & Choi, C. Y. (2023). Effects of microfiber exposure on medaka (*Oryzias latipes*): Oxidative stress, cell damage, and mortality. *Comparative Biochemistry and Physiology Part - C: Toxicology and Pharmacology*, *265*. https://doi.org/10.1016/j.cbpc.2022.109535

Kooi, M., & Koelmans, A. A. (2019). Simplifying Microplastic via Continuous Probability Distributions for Size, Shape,and Density. *Environmental Science and Technology Letters*, *6*(9), 551–557. https://doi.org/10.1021/acs.estlett.9b00379

Lee, D. H. (2018). Evidence of the possible harm of endocrine-disrupting chemicals in humans: Ongoing debates and key issues. In *Endocrinology and Metabolism* (Vol. 33, Issue 1, pp. 44–52). Korean Endocrine Society. https://doi.org/10.3803/EnM.2018.33.1.44

Liu, Y., Hu, Y., Yang, C., Chen, C., Huang, W., & Dang, Z. (2019). Aggregation kinetics of UV irradiated nanoplastics in aquatic environments. *Water Research*, *163*. https://doi.org/10.1016/j.watres.2019.114870

Long, M., Paul-Pont, I., Hégaret, H., Moriceau, B., Lambert, C., Huvet, A., & Soudant, P. (2017). Interactions between polystyrene microplastics and marine phytoplankton lead to species-specific hetero-aggregation. *Environmental Pollution*, *228*, 454–463. https://doi.org/10.1016/j.envpol.2017.05.047

Maes, T., Jessop, R., Wellner, N., Haupt, K., & Mayes, A. G. (2017). A rapid-screening approach to detect and quantify microplastics based on fluorescent tagging with Nile Red. *Scientific Reports*, *7*. https://doi.org/10.1038/srep44501

Mawaddha, R., Firdaus, & Tahir, A. (2020). Studies of Micro Plastics contamination on mussels, seawater, and sediment at Sanrobengi Island of South Sulawesi. *Advances in Environmental Biology*. https://doi.org/10.22587/aeb.2020.14.2.2

Mercogliano, R., Santonicola, S., Albrizio, S., & Ferrante, M. C. (2021). Occurrence of bisphenol A in the milk chain: A monitoring model for risk assessment at a dairy company. *Journal of Dairy Science*, *104*(5), 5125–5132. https://doi.org/10.3168/jds.2020-19365

Peng, X., Chen, M., Chen, S., Dasgupta, S., Xu, H., Ta, K., Du, M., Li, J., Guo, Z., & Bai, S. (2018). Microplastics contaminate the deepest part of the world's ocean. *Geochemical Perspectives Letters*, *9*, 1–5. https://doi.org/10.7185/geochemlet.1829

Ranjan, V. P., Joseph, A., & Goel, S. (2021). Microplastics and other harmful substances released from disposable paper cups into hot water. *Journal of Hazardous Materials*, *404*. https://doi.org/10.1016/j.jhazmat.2020.124118

Rebollar, E., Pérez, S., Hernández, M., Domingo, C., Martín, M., Ezquerra, T. A., García-Ruiz, J. P., & Castillejo, M. (2014). Physicochemical modifications accompanying UV laser induced surface structures on poly(ethylene terephthalate) and their effect on adhesion of mesenchymal cells. *Physical Chemistry Chemical Physics*, *16*(33), 17551–17559. https://doi.org/10.1039/c4cp02434f

Repossi, A., Farabegoli, F., Gazzotti, T., Zironi, E., & Pagliuca, G. (2016). Bisphenol a in edible part of seafood. In *Italian Journal of Food Safety* (Vol. 5, Issue 2, pp. 98–105). Page Press Publications. https://doi.org/10.4081/ijfs.2016.5666

Ribba, L., Lopretti, M., Montes De Oca-Vásquez, G., Batista, D., Goyanes, S., & Vega-Baudrit, J. R. (2022). Biodegradable plastics in aquatic ecosystems: Latest findings, research gaps, and recommendations. In *Environmental Research Letters* (Vol. 17, Issue 3). IOP Publishing Ltd. https://doi.org/10.1088/1748-9326/ac548d

Rodprasert, W., Toppari, J., & Virtanen, H. E. (2021). Endocrine Disrupting Chemicals and Reproductive Health in Boys and Men. In *Frontiers in Endocrinology* (Vol. 12). Frontiers Media S.A. https://doi.org/10.3389/fendo.2021.706532

Sarria-Villa, R. A., & Gallo-Corredor, J. A. (2016). La gran problemática ambiental de los residuos plásticos: Microplásticos. *Journal de Ciencia e Ingeniería*, *8*(1), 21–27.


Laboratorio Institucional de
Microscopía


MUITO
Obrigada