NUMERO 3 - MAGGIO 2024

PACKAGING SCIENCE

E' la Rassegna Scientifica Internazionale della ***Fondazione Carta Etica del Packaging.***

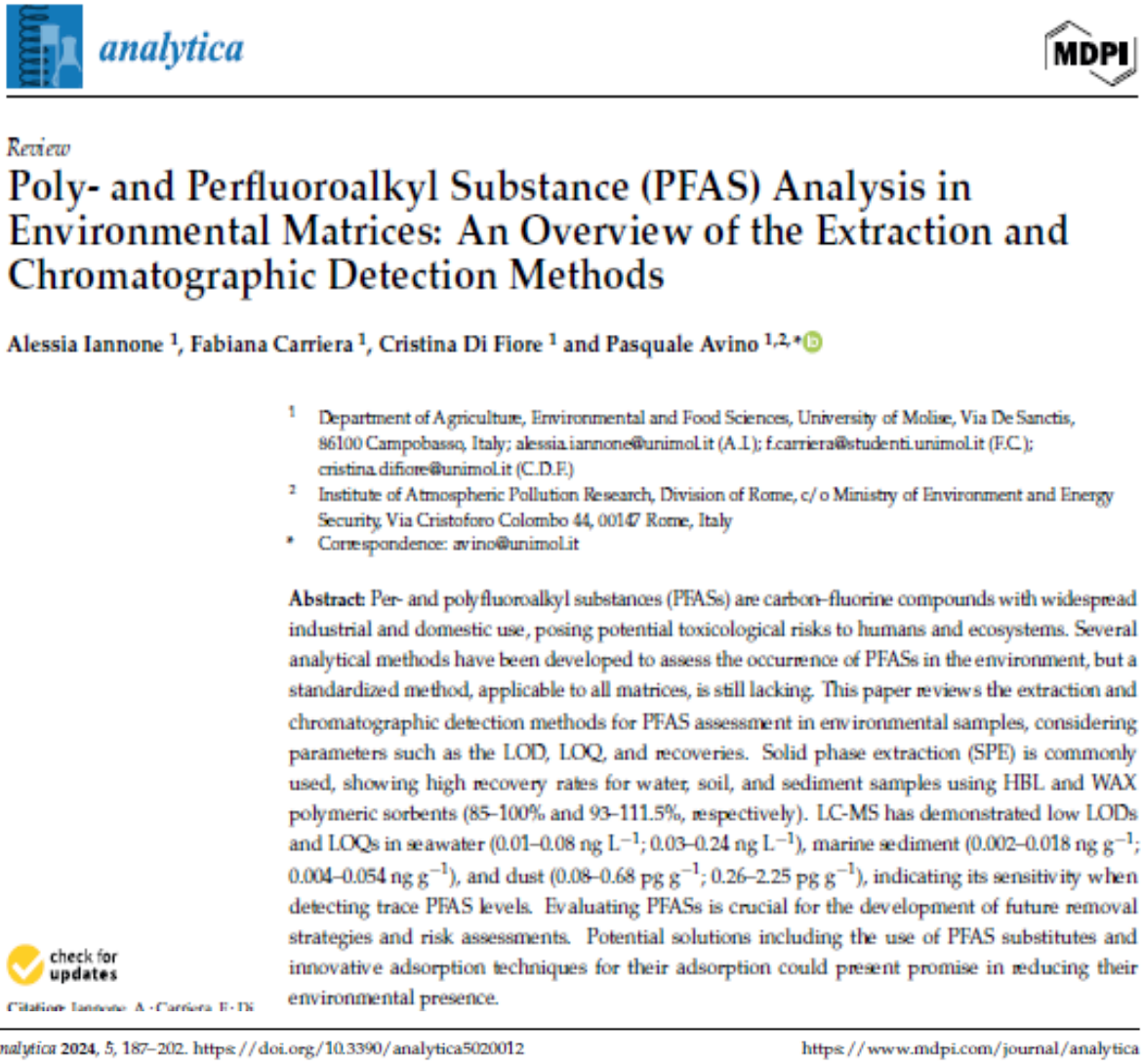
Pubblicazione bimestrale in cui sono presentati 7 articoli multidisciplinari, afferenti al packaging, selezionati da diverse riviste del mondo scientifico digitale.

Packaging Science attraverso le tematiche sempre attuali ed aggiornate dei suoi articoli in diverse discipline, concorre ampiamente alla promozione e all'evoluzione della corretta cultura del packaging e dei ***10 Valori della Carta Etica*** *per accompagnare il packaging verso un futuro più consapevole.*

FONDAZIONE™
CARTA
ETICA
del Packaging

Analisi di sostanze poli- e perfluoroalchiliche (PFAS) in matrici ambientali: una panoramica dei metodi di estrazione e rivelazione cromatografica.

Le sostanze perfluoroalchiliche e polifluoroalchiliche (PFAS) sono composti carbonio-fluoro di uso industriale e domestico diffuso, che comportano potenziali rischi tossicologici per l'uomo e gli ecosistemi. Sono stati sviluppati diversi metodi analitici per valutare la presenza di PFAS nell'ambiente, ma manca ancora un metodo standardizzato, applicabile a tutte le matrici. Questo documento esamina i metodi di estrazione e rilevamento cromatografico per la valutazione dei PFAS in campioni ambientali, considerando parametri come LOD, LOQ e recuperi.La valutazione dei PFAS è fondamentale per lo sviluppo di future strategie di rimozione e valutazioni del rischio.



analytica

MDPI

Review

Poly- and Perfluoroalkyl Substance (PFAS) Analysis in Environmental Matrices: An Overview of the Extraction and Chromatographic Detection Methods

Alessia Iannone [1], Fabiana Carriera [1], Cristina Di Fiore [1] and Pasquale Avino [1,2,*]

[1] Department of Agriculture, Environmental and Food Sciences, University of Molise, Via De Sanctis, 86100 Campobasso, Italy; alessia.iannone@unimol.it (A.I.); f.carriera@studenti.unimol.it (F.C.); cristina.difiore@unimol.it (C.D.F.)

[2] Institute of Atmospheric Pollution Research, Division of Rome, c/o Ministry of Environment and Energy Security, Via Cristoforo Colombo 44, 00147 Rome, Italy

* Correspondence: avino@unimol.it

Abstract: Per- and polyfluoroalkyl substances (PFASs) are carbon–fluorine compounds with widespread industrial and domestic use, posing potential toxicological risks to humans and ecosystems. Several analytical methods have been developed to assess the occurrence of PFASs in the environment, but a standardized method, applicable to all matrices, is still lacking. This paper reviews the extraction and chromatographic detection methods for PFAS assessment in environmental samples, considering parameters such as the LOD, LOQ, and recoveries. Solid phase extraction (SPE) is commonly used, showing high recovery rates for water, soil, and sediment samples using HBL and WAX polymeric sorbents (85–100% and 93–111.5%, respectively). LC-MS has demonstrated low LODs and LOQs in seawater (0.01–0.08 ng L^{-1}; 0.03–0.24 ng L^{-1}), marine sediment (0.002–0.018 ng g^{-1}; 0.004–0.054 ng g^{-1}), and dust (0.08–0.68 pg g^{-1}; 0.26–2.25 pg g^{-1}), indicating its sensitivity when detecting trace PFAS levels. Evaluating PFASs is crucial for the development of future removal strategies and risk assessments. Potential solutions including the use of PFAS substitutes and innovative adsorption techniques for their adsorption could present promise in reducing their environmental presence.

Analytica **2024**, *5*, 187–202. https://doi.org/10.3390/analytica5020012 https://www.mdpi.com/journal/analytica

https://www.mdpi.com/2673-4532/5/2/12

Efficienza nell'uso del materiale di imballaggio delle bottiglie commerciali in PET e vetro per l'acqua minerale.

In questo contesto, l'efficienza nell'uso del materiale come rapporto tra il volume di riempimento e il peso dell'imballaggio è più alta per le bottiglie in PET usa e getta e sarebbe, a prima vista, la scelta migliore. Tuttavia, questi fattori devono essere relativizzati perché le bottiglie di vetro per l'acqua minerale vengono riempite fino a 50 volte e le bottiglie in PET riutilizzabili fino a 25 volte. La scelta del vetro o del PET, da un lato, e delle bottiglie riutilizzabili o usa e getta, dall'altro, non è guidata solo dall'industria dell'imbottigliamento. In effetti, questa decisione deve essere presa in base alle esigenze del cliente (discount vs. rivenditore di bevande) e alla legislazione (Direttiva quadro sui rifiuti dell'UE).

beverages

MDPI

Artide

Packaging Material Use Efficiency of Commercial PET and Glass Bottles for Mineral Water

Anna Gress [1], Kajetan Müller [2,3] and Sven Sängerlaub [1,*]

[1] Sustainable Materials and Product Design, Munich University of Applied Sciences HM, Lothstraße 34, 80335 Munich, Germany; anna.gress@hm.edu
[2] Faculty of Mechanical Engineering, University of Applied Science Kempten, Bahnhofstraße 61, 87435 Kempten, Germany
[3] Fraunhofer Institute for Process Engineering and Packaging IVV, Giggenhauser Straße 35, 85354 Freising, Germany
* Correspondence: sven.saengerlaub@hm.edu

Abstract: The influence of the bottle material (glass, PET), the reusability (reusable and disposable bottles), and the carbonization (still, medium, classic mineral water) on the filling ratio, packaging material use efficiency, cost, and shelf life were evaluated. Two hundred different bottles were purchased and characterized regarding their filling volume, the weight of the bottle, the weight of the closure, the weight of the label, and the maximum full-rim volume of the bottle. The packaging material use efficiency was calculated. The shelf life was evaluated by calculating the water vapor and carbon dioxide transmission rates. The ratio of filling volume to the packaging weight of disposable PET bottles was, on average, two times higher compared to returnable PET bottles and 20 times higher compared to glass bottles. Shelf life was, on average, higher than factor two for glass bottles compared to PET bottles. On average, but not in all cases, mineral water packaged in disposable PET bottles was cheaper compared to reusable PET and glass bottles. This paper provides a benchmark for the packaging community, especially when data for life cycle assessment are required, and the different advantages and disadvantages of different bottle materials for mineral water are shown.

Beverages **2024**, *10*, 25. https://doi.org/10.3390/beverages10020025 https://www.mdpi.com/journal/beverages

https://www.mdpi.com/2306-5710/10/2/25

Rilascio di microplastiche dai bicchieri per bevande in plastica monouso.

In questo studio è stato valutato l'effetto di diversi tempi di esposizione (0, 5, 10 e 20 min) e temperature (4 °C, 50 °C e 80 °C) sul rilascio di Nicroplastiche (MP) dai bicchieri monouso realizzati con quattro diversi materiali [bicchieri di carta rivestiti in polipropilene (PP), polistirene (PS), polietilene (PE) e polistirene espanso (EPS)] nell'acqua. L'esposizione annuale di MP dei consumatori è stata calcolata come 18.720-73.840 dal consumo di bevande calde e fredde in bicchieri usa e getta. In conclusione, poiché il livello e la potenziale tossicità dell'esposizione ai MP nell'uomo non sono ancora completamente noti, questo studio fa luce sul numero di MP trasferiti alle bevande fredde e calde dai bicchieri monouso.

foods

MDPI

Article

Microplastic Release from Single-Use Plastic Beverage Cups

Selen Akbulut [1,2,*], Perihan Kubra Akman [2], Fatih Tornuk [2,3] and Hasan Yetim [4]

[1] Department of Food Technology, Vocational School of Health Services, Uskudar University, 34674 Istanbul, Türkiye
[2] Department of Food Engineering, Faculty of Chemical and Metallurgical Engineering, Yildiz Technical University, 34349 Istanbul, Türkiye; pkcicek@yildiz.edu.tr (P.K.A.); fthtrnk@gmail.com (F.T.)
[3] Department of Nutrition and Dietetics, Faculty of Health Sciences, Sivas Cumhuriyet University, 58140 Sivas, Türkiye
[4] Food Engineering Department, Faculty of Engineering and Natural Sciences, Istanbul Sabahattin Zaim University, 34303 Istanbul, Türkiye; hasan.yetim@izu.edu.tr
* Correspondence: selen.akbulut@uskudar.edu.tr

Abstract: Microplastics (MPs) have attracted considerable attention as one of the most remarkable food and drink pollutants in recent years. Disposable cups, which are widely used as single-use containers, have been suspected as the primary sources of MPs found in cold and hot beverages. In this study, the effect of different exposure times (0, 5, 10 and 20 min) and temperatures (4 °C, 50 °C and 80 °C) on MP release from the single-use cups made of four different materials [polypropylene (PP), polystyrene (PS), polyethylene (PE) coated paper cups and expanded polystyrene (EPS)] into the water was investigated. The number of MPs ranged from 126 p/L to 1420 p/L, while the highest and lowest counts were observed in the PP (50 °C for 20 min) and PE-coated paper cups (4 °C 0 min), respectively. Washing the cups with ultrapure water prior to use reduced the MP release by 52–65%. SEM images demonstrated the abrasion on the surface of the disposable cups as a result of hot water exposure. Intensities of FTIR absorbance levels at some wavelengths were decreased by the water treatment, which could be evidence of surface abrasion. The annual MP exposure of consumers was calculated as 18,720–73,840 by the consumption of hot and cold beverages in disposable cups. In conclusion, as the level and potential toxicity of MP exposure in humans are not yet fully known, this study sheds light on the number of MPs transferred to cold and hot beverages from single-use disposable cups.

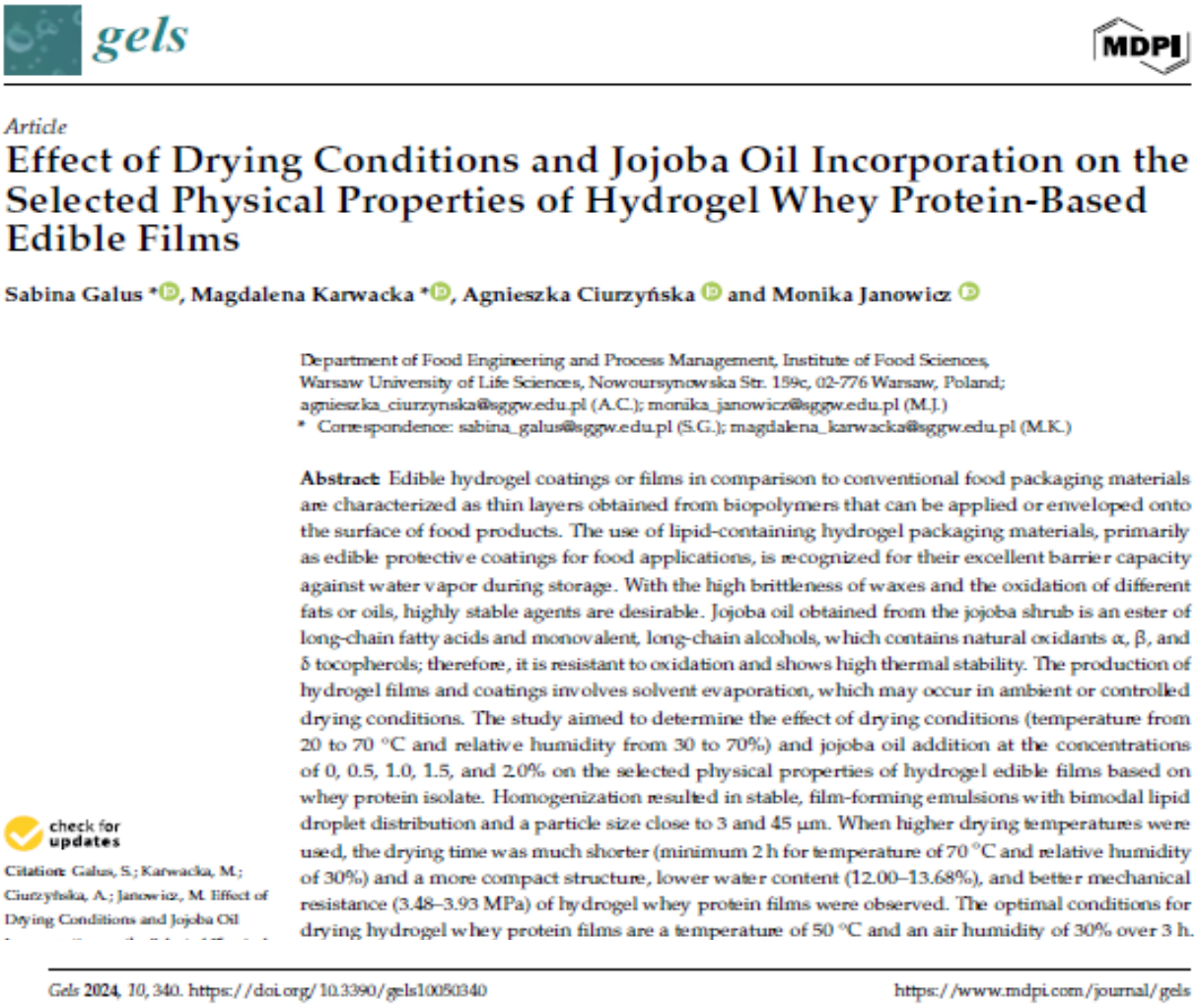
Citation: Akbulut, S.; Akman, P.K.; Tornuk, F.; Yetim, H. Microplastic

Foods **2024**, *13*, 1564. https://doi.org/10.3390/foods13101564 https://www.mdpi.com/journal/foods

https://www.mdpi.com/2304-8158/13/10/1564

Effetto delle condizioni di essiccazione e dell'incorporazione di olio di jojoba sulle proprietà fisiche selezionate delle pellicole commestibili a base di proteine del siero di latte idrogel.

I rivestimenti o i film in idrogel commestibili, rispetto ai materiali di imballaggio alimentare convenzionali, sono caratterizzati da strati sottili ottenuti da biopolimeri che possono essere applicati o avvolti sulla superficie dei prodotti alimentari. L'uso di materiali di imballaggio in idrogel contenenti lipidi, principalmente come rivestimenti protettivi commestibili per applicazioni alimentari, è riconosciuto per la loro eccellente capacità barriera contro il vapore acqueo durante lo stoccaggio. L'olio di jojoba ottenuto dall'arbusto di jojoba è un estere di acidi grassi a catena lunga e alcoli monovalenti a catena lunga, che contiene ossidanti naturali α, β e tocoferoli δ; pertanto, è resistente all'ossidazione e mostra un'elevata stabilità termica.



gels

MDPI

Article

Effect of Drying Conditions and Jojoba Oil Incorporation on the Selected Physical Properties of Hydrogel Whey Protein-Based Edible Films

Sabina Galus *, Magdalena Karwacka *, Agnieszka Ciurzyńska and Monika Janowicz

Department of Food Engineering and Process Management, Institute of Food Sciences, Warsaw University of Life Sciences, Nowoursynowska Str. 159c, 02-776 Warsaw, Poland; agnieszka_ciurzynska@sggw.edu.pl (A.C.); monika_janowicz@sggw.edu.pl (M.J.)
* Correspondence: sabina_galus@sggw.edu.pl (S.G.); magdalena_karwacka@sggw.edu.pl (M.K.)

Abstract: Edible hydrogel coatings or films in comparison to conventional food packaging materials are characterized as thin layers obtained from biopolymers that can be applied or enveloped onto the surface of food products. The use of lipid-containing hydrogel packaging materials, primarily as edible protective coatings for food applications, is recognized for their excellent barrier capacity against water vapor during storage. With the high brittleness of waxes and the oxidation of different fats or oils, highly stable agents are desirable. Jojoba oil obtained from the jojoba shrub is an ester of long-chain fatty acids and monovalent, long-chain alcohols, which contains natural oxidants α, β, and δ tocopherols; therefore, it is resistant to oxidation and shows high thermal stability. The production of hydrogel films and coatings involves solvent evaporation, which may occur in ambient or controlled drying conditions. The study aimed to determine the effect of drying conditions (temperature from 20 to 70 °C and relative humidity from 30 to 70%) and jojoba oil addition at the concentrations of 0, 0.5, 1.0, 1.5, and 2.0% on the selected physical properties of hydrogel edible films based on whey protein isolate. Homogenization resulted in stable, film-forming emulsions with bimodal lipid droplet distribution and a particle size close to 3 and 45 µm. When higher drying temperatures were used, the drying time was much shorter (minimum 2 h for temperature of 70 °C and relative humidity of 30%) and a more compact structure, lower water content (12.00–13.68%), and better mechanical resistance (3.48–3.93 MPa) of hydrogel whey protein films were observed. The optimal conditions for drying hydrogel whey protein films are a temperature of 50 °C and an air humidity of 30% over 3 h.

Citation: Galus, S.; Karwacka, M.; Ciurzyńska, A.; Janowicz, M. Effect of Drying Conditions and Jojoba Oil

Gels **2024**, *10*, 340. https://doi.org/10.3390/gels10050340 https://www.mdpi.com/journal/gels

https://www.mdpi.com/2310-2861/10/5/340

Un modello meccanico per il rilassamento delle sollecitazioni di miscele di acido polilattico/poliuretano termoplastico

L'acido polilattico (PLA) è stato considerato un'alternativa biodegradabile promettente ai tradizionali petropolimeri grazie alle sue interessanti proprietà meccaniche, all'elevata rinnovabilità, alla buona biodegradabilità e al costo relativamente basso. Sebbene il PLA abbia proprietà meccaniche migliori rispetto ai polimeri di base come polistirene, polietilene e polietilene tereftalato, è fragile, ha una bassa resistenza agli urti e ha un basso grado di cristallizzazione. I materiali compositi realizzati mediante fusione di poliuretano termoplastico (TPU) con PLA possono migliorare la tenacità del PLA.

Journal of Composites Science

MDPI

Article

A Mechanical Model for Stress Relaxation of Polylactic Acid/Thermoplastic Polyurethane Blends

Yi-Sheng Jhao [1], Hao Ouyang [1], Chien-Chao Huang [2], Fuqian Yang [3] and Sanboh Lee [1,*]

1 Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu 300, Taiwan
2 College of Semiconductor Research, National Tsing Hua University, Hsinchu 300, Taiwan
3 Materials Program, Department of Chemical and Materials Engineering, University of Kentucky, Lexington, KY 40506, USA
* Correspondence: sblee@mx.nthu.edu.tw; Tel.: +886-3-5719677

Abstract: Polylactic acid (PLA) is considered a promising biodegradable polymer alternative. Due to its high brittleness, composite materials made by melt blending thermoplastic polyurethane (TPU) with PLA can enhance the toughness of PLA. To understand the forced aging caused by stress relaxation in polymer materials, this study explains the stress relaxation experiments of PLA/TPU blends with different mass ratios under applied strain through mechanical model simulations. The Kelvin representation of the standard linear solid model (SLSM) is used to analyze the stress relaxation data of TPU/PLA blends, successfully explaining that the Young's moduli (E_1 and E_2) of springs decrease with increasing temperature and TPU content. The viscosity coefficient of the PLA/TPU blends decreases with increasing temperature, and its reciprocal follows the Arrhenius law. For TPU/PLA blends with increased concentration of TPU, the activation energy for stress relaxation shows a linear decrease, confirmed by the glass transition point measured by DMA, indicating that it does not involve chemical reactions.

J. Compos. Sci. **2024**, *8*, 169. https://doi.org/10.3390/jcs8050169 https://www.mdpi.com/journal/jcs

https://www.mdpi.com/2504-477X/8/5/169

Rivestimenti ingegnerizzati in nanomateriali per imballaggi alimentari: implicazioni di progettazione, produzione, regolamentazione e sostenibilità.

Questo articolo di revisione evidenzia il ruolo dei nanomateriali nella progettazione e produzione di rivestimenti antivegetativi e antimicrobici per l'industria dell'imballaggio alimentare. Viene discusso l'uso di rivestimenti nanotecnologici come pellicole protettive e sensori per indicare i livelli di qualità degli alimenti. Inoltre, viene sviluppata la loro valutazione della sostenibilità normativa e ambientale. Questa revisione fornisce una prospettiva completa sui rivestimenti nanotecnologici in grado di garantire una nutrizione di alta qualità in tutte le fasi della catena alimentare, compresi i sistemi di imballaggio alimentare per scopi umanitari.

micromachines

MDPI

Review

Engineered Nanomaterial Coatings for Food Packaging: Design, Manufacturing, Regulatory, and Sustainability Implications

Oluwafemi Olawore [1], Motunrayo Ogunmola [1] and Salil Desai [1,2,*]

[1] Department of Industrial and Systems Engineering, North Carolina Agricultural and Technical State University, Greensboro, NC 27411, USA; oolawore@aggies.ncat.edu (O.O.); maogunmola@aggies.ncat.edu (M.O.)
[2] Center of Excellence in Product Design and Advanced Manufacturing, North Carolina Agricultural and Technical State University, Greensboro, NC 27411, USA
* Correspondence: sdesai@ncat.edu; Tel.: +1-336-285-3725

Abstract: The food industry is one of the most regulated businesses in the world and follows strict internal and regulated requirements to ensure product reliability and safety. In particular, the industry must ensure that biological, chemical, and physical hazards are controlled from the production and distribution of raw materials to the consumption of the finished product. In the United States, the FDA regulates the efficacy and safety of food ingredients and packaging. Traditional packaging materials such as paper, aluminum, plastic, and biodegradable compostable materials have gradually evolved. Coatings made with nanotechnology promise to radically improve the performance of food packaging materials, as their excellent properties improve the appearance, taste, texture, and shelf life of food. This review article highlights the role of nanomaterials in designing and manufacturing anti-fouling and antimicrobial coatings for the food packaging industry. The use of nanotechnology coatings as protective films and sensors to indicate food quality levels is discussed. In addition, their assessment of regulatory and environmental sustainability is developed. This review provides a comprehensive perspective on nanotechnology coatings that can ensure high-quality nutrition at all stages of the food chain, including food packaging systems for humanitarian purposes.

Micromachines **2024**, *15*, 245. https://doi.org/10.3390/mi15020245 https://www.mdpi.com/journal/micromachines

https://www.mdpi.com/2072-666X/15/2/245#B202-micromachines-15-00245

Inquinamento da plastica e micro/nanoplastica nell'Africa sub-sahariana: sfide, impatti e soluzioni.

L'Africa subsahariana deve affrontare livelli crescenti di produzione e importazione di plastica, un uso non regolamentato e sistemi di gestione dei rifiuti inadeguati. Le dure condizioni di questa regione spesso portano alla scomposizione della plastica in microplastiche e nanoplastiche. Questa revisione esplora l'abbondanza di micro/nanoplastiche in diversi mezzi ambientali, come acque superficiali, sedimenti e organismi acquatici, nei paesi dell'Africa subsahariana. Evidenzia inoltre le lacune nelle conoscenze relative all'abbondanza di micro/nanoplastiche nella regione.

world

MDPI

Review

Plastic and Micro/Nanoplastic Pollution in Sub-Saharan Africa: Challenges, Impacts, and Solutions

Edith Dube * and Grace Emily Okuthe

Department of Biological & Environmental Sciences, Walter Sisulu University, Mthatha 5117, South Africa; gokuthe@wsu.ac.za

* Correspondence: edube@wsu.ac.za; Tel.: +27-47-502-1952; Fax: +27-47-5022725

Abstract: Sub-Saharan Africa faces increasing levels of plastic production and importation, unregulated usage, and inadequate waste management systems. This region's harsh conditions often lead to plastic breaking down into microplastics and nanoplastics. This review explores the abundance of micro/nanoplastics across different environmental mediums, such as surface waters, sediments, and aquatic organisms, in sub-Saharan African countries. It also highlights knowledge gaps concerning the region's abundance of micro/nanoplastics. The effects of plastics and micro/nanoplastics on food production, water quality, health, and the environment are discussed. Strategies to address the challenges of plastic pollution are proposed. Finally, the review concludes with future perspectives for addressing the ongoing challenges of plastic waste management in sub-Saharan Africa. The materials for this study were sourced from published articles on Scopus, Google Scholar, ResearchGate, and additional platforms, including reports and various press releases, using keywords such as plastic waste, micro/nano-plastic, sub-Saharan Africa, toxicity, and circular economy. Articles were initially screened by reviewing abstracts, followed by a thorough reading of full papers to identify relevant studies. Key information was extracted from these selected articles and incorporated into this review.

World **2024**, *5*, 325–345. https://doi.org/10.3390/world5020018 https://www.mdpi.com/journal/world

https://www.mdpi.com/2673-4060/5/2/18

FONDAZIONE™
CARTA
ETICA
del Packaging

Via Cosimo Del Fante 10 - 20122 Milano - Tel. +39 02 58319624
C.F: 97870780158
segreteria@fondazionepackaging.org - www.fondazionecartaeticapackaging.org