CHEMWATCH

Bulletin Board

Contents

SEP. 19, 2025

(click on page numbers for links)

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CHEMICAL EFFECTS

Carbon dots as dual-action nanotools for metal toxicity recognition and mitigation

2025-09-12

Carbon dots (CDs) have emerged as promising agents for mitigating metal toxicity and monitoring metal contamination in aquatic environments. This study investigated the dual functionality of CDs as anti-toxicity agents and biosensors for cadmium (Cd2+), nickel (Ni2+), and silver (Ag+) in a zebrafish embryo model. Zebrafish embryos were exposed to various concentrations of CDs (0, 5, and 50 mg L-1) in combination with different metal concentrations. Toxicity was assessed by measuring the lethality, hatching rate, swimming activity, and AChE activity. CDs significantly reduced the lethal toxicity of all tested metals, with LC50 values increasing from 56.0 to 110.0 μM for Cd2+, 0.4-1.6 μM for Ag+, and becoming undeterminable for Ni2+ at the highest CDs concentration. Photophysical characterization revealed that the CDs exhibited metal-specific fluorescence, enabling the development of an optical fingerprint for metal identification. Fluorescence imaging of zebrafish embryos demonstrated the effectiveness of CDs as in vivo tracers of metallic contaminants, highlighting their utility in studying biological processes. These findings highlight the dual functionality of CDs as agents to reduce metal toxicity and as monitoring tools for water quality assessment, making them a versatile solution for addressing metal contamination challenges in aquatic and biological systems. ENVIRONMENTAL IMPLICATIONS: The present study explores the potential of carbon dots as nanotools for water remediation. Carbon dots have a high absorption capacity and can remove several compounds, including metals, from aquatic environments. This is highly relevant because contamination by metallic compounds is an environmental concern and that technology is constantly being sought to minimize the impact of these compounds on aquatic systems. Due to natural fluorescence which can be changed by metallic ions, carbon dots also show potential for monitoring aquatic contamination contributing as a potential tool in risk assessment strategies.

Authors: Inês Domingues, João Amaral, Bruna Vieira, Ana Luísa Machado, Carla I M Santos, Joana P M Sousa, Alice Sciortino, Roberta Cillari, Radian Popescu, Yolita M Eggeler, Fabrizio Messina, Nicolò Mauro, Gil Gonçalves

Full Source: Environmental research 2025 Sep 12;286(Pt 1):122851. doi: 10.1016/j.envres.2025.122851.

CHEMWATCH
Bulletin Board
Technical
SEP. 19, 2025

Aluminum Induced Higher Neurotoxicity than Nano-Alumina During Early Development in Zebrafish, Exacerbated by Trem2 Knockdown

2025-09-13

Early exposure to toxic substances is a known risk factor for neurotoxicity. The present study is aimed at exploring the neurotoxicity of nano-alumina (AlNPs) and aluminum chloride (AlCl3) in zebrafish at 144 h post-fertilization (hpf) and at investigating the role of the type II triggering receptor expressed on myeloid cells (trem2) among them. Zebrafish embryos within the four-cell stage were exposed to control, negative control, trem2 knockdown, AlCl3, AlCl3 + trem2 knockdown, AlNPs, and AlNPs + trem2 knockdown until 144 hpf. 500 pL of lentivirus containing trem2 inhibitor at 5 × 108 TU/mL was microinjected into the yolk sacs to achieve trem2 knockdown. AlCl3 and AlNPs were applied at 50 mg/L. Neurobehavior, AChE and SOD levels, and the expression of trem2 and neurodevelopmental genes were measured. AlNPs significantly increased the average speed while decreasing the absolute angle compared to AlCl3. Upon trem2 knockdown, time spent in the outer zone, distance travelled, and accelerated speed were further reduced in both AlCl3 and AlNPs groups. The trem2 loss also exacerbated the suppression of AChE and SOD levels, trem2, α1-tubulin, and mbp gene levels in the AlCl3 and AlNPs groups. In conclusion, AlCl3 induced higher neurotoxicity than AlNPs, and these effects were intensified by trem2 knockdown. Studying larvae allows us to capture neurodevelopmental disturbances during critical stages of brain formation, offering a more comprehensive assessment of the risks and therapeutic potential of targeting trem2 in Al- and AlNPs-induced neurotoxicity.

Authors: Ying Zhang, Xinyue Guo, Jinjin Zhao, Xiaocheng Gao, Lan Zhang, Tao Huang, Yanhong Wang, Qiao Niu, Qinli Zhang

Full Source: Biological trace element research 2025 Sep 13. doi: 10.1007/s12011-025-04790-z.

Identification of key factors bioconcentration potential of organic chemicals in fish by integrating multimodal learning and ensemble learning strategies

2025-09-02

Assessing the bioconcentration potential of chemicals is crucial for environmental risk assessment, yet traditional experimental methods for measuring bioconcentration factors (BCF) values are inefficient, underscoring the need for prediction models. While existing

computational models were often reliant on single machine learning (ML) algorithms and limited feature spaces, which limit prediction accuracy and applicability. To address these limitations, this study integrated ensemble learning (EL) strategies and multimodal learning (MML) to develop a robust predictive framework. By combining numerical information (molecular descriptors/fingerprints) with textual (categorical features), the proposed MML-EL approach showed better performance over single-model baselines, achieving a coefficient of determination of up to 0.857 on the validation sets, enhanced generalization capacity. Applicability domain (AD) characterization was a structure-activity landscape (SAL) methodology based on weighted similarity density (PS) and activity inconsistency (IA). Model interpretability was further enhanced using Shapley additive explanations, identifying key structural and categorical features driving predictions. Results showed that fish species and hydrocarbon groups are important promoting units in bioconcentration potential. Overall, the MML-EL model with a state-of-the-art SAL-based AD can provide an effective tool for bioconcentration assessment of chemicals based on background information, providing some valuable insights to advance chemical risk management and regulation.

Authors: Xuanzhi Dong, Hongxia Zhao, Ying Liu, Baocheng Qu, Siyu Liu, Bing Xiao

Full Source: Journal of hazardous materials 2025 Sep 2:498:139761. doi: 10.1016/j.jhazmat.2025.139761.

ENVIRONMENTAL RESEARCH

Environmental impacts and optimization strategies for integrating carbon capture and anammox-based processes in municipal wastewater treatment under uncertain influent parameters

2025-09-12

The anaerobic ammonia oxidation (anammox) process is increasingly recognized as an effective alternative to conventional activated sludge processes for reducing energy consumption and carbon emissions in municipal wastewater treatment. This study evaluates the environmental impact of integrating the anaerobic membrane bioreactor (AnMBR) or high-rate activated sludge (HRAS) with anammox-based, considering sludge treatment: anaerobic digestion (AD) and incineration. The Monte Carlo simulations (10,000 iterations) results reveal that AnMBR and Anammox process combined with AD reduces the carbon footprint by

CHEMWATCH
Bulletin Board
Technical
SEP. 19, 2025

30 %-50 % and increases energy recovery by 146.8 %-320 %. The AnMBR scenarios exhibit low carbon emissions and energy consumption owing to energy recovery from biogas production at high chemical oxygen demand (COD) concentrations (>200 mg/L). The HRAS schemes are recommended for nitrogen concentrations exceeding 40 mg/L and COD concentrations below 150 mg/L. Applicating carbon capture and anammox in municipal wastewater treatment provides a promising pathway toward achieving carbon neutrality and energy neutrality.

Authors: Rui Zhou, Ying Zhu, Qian Li, Rong Chen, Yu-You Li

Full Source: Bioresource technology 2025 Sep 12:133326. doi: 10.1016/j.biortech.2025.133326.

Ambient air pollution and incident dementia: exploration of relevant exposure windows

2025-09-12

Background: As dementia has a decades-long preclinical phase, earlier air pollution exposures may be more etiologically relevant to dementia risk than more recent exposures.

Methods: We estimated exposures at Atherosclerosis Risk in Communities (ARIC) study participant addresses to criteria air pollutants, PM components, and trace metals in several exposure windows (1990-1994, 1995-1999, 2000-2004, 2005-2009, and 1990-2009) using a chemical transport model with observation data fusing at two resolutions, 4km (CTM-4k) and finest available resolution (CTM-FR), and to PM2.5, ozone, and NO2 using universal kriging with land-use regression and partial least squares regression (UK-LUR-PLSR). We estimated the association between each exposure/exposure window and incident dementia from ARIC Visit 5 (2011-2013) to Visit 7 (2018-2019).

Results: During follow-up (mean: 6.1 years) of 5,621 participants (mean baseline age: 76 years), 828 (14.7%) developed dementia. Analyses did not support an association between most air pollutant exposures in any exposure window and incident dementia. However, we observed stronger associations in later time periods for PM2.5, with significant associations in the latest time period with one exposure estimation approach: (HR (95% CI) per 1 ug/m3 higher 2005-2009 PM2.5 exposure for CTM-FR: 1.11 (0.99, 1.25); CTM-4k: 1.07 (0.89, 1.22), UK-LUR-PLSR: 1.13 (1.03, 1.24). We saw similar patterns for NO2, elemental carbon, Ni, and V.

Discussion: We found little evidence supporting the hypothesized greater etiologic relevance of earlier exposures on incident dementia. Spatial

confounding or acceleration of pathologic processes may explain the stronger associations observed with later exposure windows.
Authors: Melinda C Power, Katie M Lynch, Vixey Fang, Qi Ying, Eun Sug Park, Richard L Smith, James D Stewart, Jeff D Yanosky, Eric A Whitsel, Xiaohui Xu
Full Source: Environmental research 2025 Sep 12:122850. doi: 10.1016/j.envres.2025.122850.

PHARMACEUTICAL/TOXICOLOGY

Per- and polyfluoroalkyl substances (PFAS) in landfill leachate, condensate, and groundwater: Characterization by landfill age and evaluation of activated carbon, ion exchange, and electrochemical treatment

2025-09-12
Municipal landfills contain elevated PFAS in leachate and gas condensate which can contaminate groundwater and burden wastewater treatment facilities. Gas condensate and leachate were collected from young (primarily active in the last 5 years) and mature (active 1960's to 2010's) municipal landfill piles, together with groundwater and leachate at point-of-discharge. The sum of 30 analyzed PFAS ranged from 0.11 µg/L in groundwater to 8.8 µg/L in young leachate, with young landfill samples containing twice the PFAS of mature samples. Batch adsorption tests found ion exchange (IEX) outperforms granular activated carbon (GAC) based on higher PFAS affinity (up to Freundlich K = 393 µg/g/µg/L, n = 1.0) and uptake (pseudo-first order rate constant k1= 0.03-0.05/min). Poor dissolved organic carbon (DOC) uptake was observed for both GAC and IEX (10-20% removal), while bicarbonate uptake coupled with chloride release (equivalent to 30-50% resin capacity) confirms electrostatic exchange even in saline leachate. Batch electrochemical treatment was less effective at treating young leachate than mature leachate, achieving 50% removal of ΣPFAS after 12 h in the former compared to near-complete removal for mature leachate. Higher organic content and chloride in young leachate (DOC = 2 g/L, chloride = 1 g/L) than mature leachate (DOC = 1.5 g/L, chloride = 0.5 g/L) resulted in significant energy diversion (DOC removal 65%) to the detriment of PFAS destruction. IEX and electrochemical treatment achieve significant PFAS removal from landfill condensate and leachate, with mature landfill waste emerging as a strategic target for further treatment testing.
Authors: William Szu-Wei Chen, Ehsan Banayan Esfahani, Fatemeh Asadi Zeidabadi, Tanya Fernandes, Madjid Mohseni
Full Source: Journal of environmental management 2025 Sep 12:394:127278. doi: 10.1016/j.jenvman.2025.127278.

Beyond smoking: A geospatial investigation of factors associated with lung and bronchus cancer risk in Pennsylvania

2025-08-14
Introduction: While smoking is the leading cause of lung and bronchus cancer (LBC), additional exposures have been implicated and may explain the rise in LBC among never-smokers. To better understand the spatial distribution of LBC incidence and associated risk factors, this study aims to identify geographic areas with significantly elevated incidence rates in Pennsylvania and investigate the potential underlying risk factors.
Methods: Using cancer registry data aggregated to the census tract level, spatial scan statistics were applied to detect areas of higher-than-expected LBC incidence across the state. Associations were then tested between census tract inclusion in a high-incidence area and eight area-level risk factors, including behavioral (e.g., smoking prevalence), environmental (e.g., PM2.5), built environment (e.g., traffic density, housing age), and socioeconomic (e.g., poverty, race) and occupational (e.g., construction work) characteristics.
Results: Twenty-two geographic areas of higher-than-expected LBC incidence were identified. Smoking rates, PM2.5, traffic density, old homes, and population density were found to be positively associated with inclusion in one of these areas. All high LBC areas had higher rates of smoking than the remainder of Pennsylvania, 20 were also high on PM2.5, traffic, or both; 19 had elevated rates of old housing.
Conclusion: By evaluating multiple factors simultaneously, this study provides a more nuanced understanding of how exposures interact to shape geographic variation in LBC incidence. This multifactorial, spatially explicit approach also assesses whether area-based environmental and socioeconomic risks contribute to LBC burden independently of smoking rates, thus informing targeted prevention strategies and future research.
Authors: Tesla D DuBois, Daniel Wiese, Kevin A Henry, Shannon M Lynch
Full Source: Social science & medicine (1982) 2025 Aug 14:384:118485. doi: 10.1016/j.socscimed.2025.118485.

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The effects of e-cigarette use on asthma severity in adult BALB/c mice

2025-09-14
Electronic cigarettes (e-cigarettes) are often perceived to be a less harmful alternative to tobacco cigarettes. Potentially due to this perception, they are used by people with pre-existing respiratory conditions, such as asthma, who otherwise would not smoke. Despite this, there are few studies exploring the health effects of e-cigarette use on pre-existing asthma. In this study, a house dust mite-induced allergic-airways disease phenotype was generated in adult BALB/c mice over 7 weeks. For the last 2 weeks of this period, mice were also exposed to either medical air, or tobacco smoke or e-cigarette aerosol (with or without nicotine) for 2 h/day. Twenty-four hours later, respiratory parameters including lung volume/function and responsiveness to methacholine were assessed. Biological samples were taken for analysis of pulmonary cellular inflammation and mediator levels, serum IgE and lung/airway structure. There were complex effects of exposure on respiratory outcomes. For example, tobacco smoke-exposed mice of both sexes were the most responsive to methacholine but had suppressed total cellular and eosinophilic inflammation. Female e-cigarette aerosol-exposed mice had impaired parenchymal mechanics at functional residual capacity compared with tobacco smoke-exposed mice, irrespective of nicotine. Interferon γ levels were suppressed in both e-cigarette-exposed groups. There was no effect of any exposure on IgE or lung structural parameters. E-cigarette aerosol exposure exacerbated aspects of an allergic airways disease phenotype in mice. This suggests that asthmatics should exercise increased caution if thinking of using e-cigarettes.
Authors: Jenield J D'abreo, Emily K Chivers, Peter B Noble, Luke J Berry, Rachel R Huxley, Arthur Bill W Musk, Peter J Franklin, Benjamin J Mullins, Katherine R Landwehr, Alexander N Larcombe
Full Source: Experimental physiology 2025 Sep 14. doi: 10.1113/EP092959.

CHEMWATCH
Bulletin Board
Technical
SEP. 19, 2025

OCCUPATIONAL

Advancements in Artificial Intelligence and Machine Learning for Occupational Risk Prevention: A Systematic Review on Predictive Risk Modeling and Prevention Strategies

2025-09-02
Background: Occupational risk prevention is a critical discipline for ensuring safe working conditions and minimizing accidents and occupational diseases. With the rise of artificial intelligence (AI) and machine learning (ML), these approaches are increasingly utilized for predicting and preventing workplace hazards. This systematic review aims to identify, evaluate, and synthesize existing literature on the use of AI algorithms for detecting and predicting hazardous environments and occupational risks in the workplace, focusing on predictive modeling and prevention strategies. Methods: A systematic literature review was conducted following the PRISMA 2020 protocol, with minor adaptations to include conference proceedings and technical reports due to the topic's emerging and multidisciplinary nature. Searches were performed in IEEE Digital Library, PubMed, Scopus, and Web of Science, with the last search conducted on 1 August 2024. Only peer-reviewed articles published from 2019 onwards and written in English were included. Systematic literature reviews were explicitly excluded. The screening process involved duplicate removal (reducing 209 initial documents to 183 unique ones), a preliminary screening based on titles, abstracts, and keywords (further reducing to 92 articles), and a detailed full-text review. During the full-text review, study quality was assessed using six quality assessment (QA) questions, where articles receiving a total score below 4.5 or 0 in any QA question were excluded. This rigorous process resulted in the selection of 61 relevant articles for quantitative and qualitative analysis. Results: The analysis revealed a growing interest in the field, with a clear upward trend in publications from 2021 to 2023, and a continuation of growth into 2024. The most significant contributions originated from countries such as China, South Korea, and India. Applications primarily focused on high-risk sectors, notably construction, mining, and manufacturing. The most common approach involved the use of visual data captured by cameras, which constituted over 40% of the reviewed studies, processed using deep learning (DL) models, particularly Convolutional Neural Networks (CNNs) and You Only Look Once (YOLO). Conclusions: The study highlights current limitations, including an over-reliance on visual data (especially

challenging in low-visibility environments) and a lack of methodological standardization for AI-based risk detection systems. Future research should emphasize the integration of multimodal data (visual, environmental, physiological) and the development of interpretable AI models (XAI) to enhance accuracy, transparency, and trust in hazard detection systems. Addressing long-term societal implications, such as privacy and potential worker displacement, necessitates transparent data policies and robust regulatory frameworks.

Authors: Pablo Armenteros-Cosme, Marcos Arias-González, Sergio Alonso-Rollán, Sergio Márquez-Sánchez, Albano Carrera

Full Source: Sensors (Basel, Switzerland) 2025 Sep 2;25(17):5419. doi: 10.3390/s25175419.

Exposure to Metal Mixtures and Childhood Adiposity: An Examination of Periods of Heightened Susceptibility Between Gestation and Late Childhood

2025-09-14

Introduction: Childhood obesity is a public health concern. Studies have investigated the effects of metal mixtures on childhood obesity but none have identified periods of heightened susceptibility of exposure. We identified the periods by investigating the association of metal mixture, measured at four time points, with adiposity.

Materials and methods: Using data from the Maternal-Infant Research on Environmental Chemicals Research Platform, we included 234 child-parent pairs. We measured whole blood metal concentrations during the first and third trimesters, early and late childhood. Outcomes were late childhood body mass index z-score (zBMI), body fat percentage (%BF) and waist circumference z-score (zWC). We used treed distributed lag mixture models (TDLMM) to investigate associations between metal mixture and adiposity. We also investigated associations using linear regression and conducted sex-specific analysis.

Results: Among females, arsenic was positively associated with zBMI and zWC. Regression results show that each doubling in third trimester arsenic concentrations was associated with 0.16 (95% CI: 0.02, 0.31) and 0.13 (95% CI: 0.01, 0.25) increase in zBMI and zWC, respectively. TDLMM results were similar but attenuated. We also observed negative associations between third trimester cadmium and zWC, null associations between other metals and adiposity and among males and no metal interactions.