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CONTACT US

subscribers@chemwatch.net

tel +61 3 9572 4700

fax +61 3 9572 4777

1227 Glen Huntly Rd

Glen Huntly

Victoria 3163 Australia

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CHEMICAL EFFECTS

Interaction of copper with titanium dioxide nanoparticles induced hematological and biochemical effects in *Clarias gariepinus*

2021-07-13

The increasing demand for engineered nanomaterials induces potential harmful impact into aquatic ecosystems and is a great concern for freshwater biodiversity. The present study showed that enhancing toxic property of titanium dioxide nanoparticles (TiO₂ NPs) with copper (Cu) was responsible for the disruption of hormonal, hematological, and biochemical activities, in *Clarias gariepinus*. The study revealed that *C. gariepinus* intravenously injected with safe concentrations of TiO₂ NPs (3 μg/g) and Cu (2.5 μg/g) alone and binary mixtures (TiO₂ NPs (3 μg/g) + Cu (2.5 μg/g)) for a period of 96h remarkably changed hormonal activities and hematological and biochemical indices of the fish. Our findings indicated that both chemicals accumulated in vital organs (the brain, serum, heart, gonad, liver, gills, serum, and kidney) and the presence of TiO₂ NPs enhanced the bioavailability of copper. Fish exposed to TiO₂ NPs alone significantly increased thyroxine (T₄) and further decreased triiodothyronine (T₃). In addition, the binary mixtures showed antagonistic effects on both hormones. The hematological indices (WBC, RBC, HgT, MCV, MCH, MCHC, and Hct) were altered in all treatment groups. Decrease in WBC, RBC, HgT, Hct, and MCV were observed. Furthermore, the co-exposure further decreased WBC (60.28%), RBC (47.10%), HgT (75.99%), Hct (25.34%), and MCV (16.18%), in contrast, MCH and MCHC increased by of 2 folds, respectively. Metabolic enzymes alanine aminotransferase (ALT), aspartate aminotransferase (AST), and lactate dehydrogenase (LDH) showed significant ($p < 0.05$) increase, with additive effect in co-exposure. However, the alkaline phosphatase (ALP) activity decreased significantly in co-exposure. Significant ($p < 0.05$) decrease of antioxidants, superoxide dismutase (SOD), glutathione transferase (GST), catalase (CAT), and metallothionein (Met) was observed in all the treatments with additive effect of 64.9%, 30.77%, and 91.31% in SOD, GST, and CAT, respectively. However, there was an increase in lipid peroxidation (MDA) in all treated fish. The results indicate that combined mixture influences the

The increasing demand for engineered nanomaterials induces potential harmful impact into aquatic ecosystems and is a great concern for freshwater biodiversity.

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accumulation, hormonal, hematological, and biochemical factors which could affect the health of the fish.

Authors: Moise Matouke Matouke, Hussaina Mohammed Sanusi, Abalaka Samson Enejo

Full Source: Environmental science and pollution research international 2021 Jul 13. doi: 10.1007/s11356-021-15148-y.

Luteolin mitigates potassium dichromate-induced nephrotoxicity, cardiotoxicity and genotoxicity through modulation of Kim-1/Nrf2 signaling pathways

2021-07-16

Environmental and occupational exposure to chromium compounds has become potential aetiologic agent for kidney disease with excessive generation of free radicals, apoptosis, and inflammatory. These pathophysiologic mechanisms of potassium dichromate (K₂Cr₂O₇) have been well correlated with nephrotoxicity and cardiotoxicity. The cardioprotective and nephroprotective effects of Luteolin, a known potent antioxidant were evaluated in this study with 40 healthy rats in four experimental groups: Group A (normal saline), Groups B (30 mg/kg K₂Cr₂O₇), Group C (Luteolin 100 mg/kg and K₂Cr₂O₇ 30 mg/kg), and Group D (Luteolin 200 mg/kg and K₂Cr₂O₇ 30 mg/kg), respectively. Markers of antioxidant defense system, oxidative stress, blood pressure and micronucleated polychromatic erythrocytes (MnPEs), immunohistochemistry of Kidney, injury molecule (Kim-1), nuclear factor erythroid 2-related factor 2 (Nrf2), and cardiac troponin I were determined. Administration of K₂Cr₂O₇ increased blood pressure parameters in systolic, diastolic and mean arterial blood pressures, markers of oxidative stress, and frequency of micronucleated polychromatic erythrocytes, together with reduction in serum nitric oxide level. Renal Kim-1 and cardiac troponin I expressions were higher, but lower expressions of renal and cardiac Nrf2 were recorded with immunohistochemical analysis. Pre-treatment with Luteolin restored blood pressure parameters, with concomitant reduction in oxidative stress indicators, augmented antioxidant mechanisms and serum Nitric oxide level, lowered the expressions of Kim-1, cardiac troponin I and up-regulated of both cardiac and renal Nrf2, reduced the frequency of micronucleated polychromatic erythrocytes. Taken together, this study therefore demonstrates the cardioprotective, nephro protective and antigenotoxic effects of Luteolin through antioxidant and radical scavenging mechanisms.

Authors: Omolola Victoria Awoyomi, Yemisi Dorcas Adeoye, Ademola Adetokunbo Oyagbemi, Temitayo Olabisi Ajibade, Ebunoluwa Rachael

Environmental and occupational exposure to chromium compounds has become potential aetiologic agent for kidney disease with excessive generation of free radicals, apoptosis, and inflammatory.

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Asenuga, Idayat Titilayo Gbadamosi, Blessing Seun Ogunpolu, Olufunke Olubunmi Falayi, Fasilat Oluwakemi Hassan, Temidayo Olutayo Omobowale, Oluwatosin Adetola Arojoye, Olufunke Eunice Ola-Davies, Adebowale Benard Saba, Adeolu Alex Adedapo, Oluwafemi Omoniyi Oguntibeju, Momoh Audu Yakubu
Full Source: Environmental toxicology 2021 Jul 16. doi: 10.1002/tox.23329.

Development of QSAR models for evaluating pesticide toxicity against *Skeletonema costatum*

2021-07-06

Nowadays, the emergence of pesticides and its application in agriculture greatly improved the crop quality and food production. However, the resulted ecological problem caused by the widespread pesticide residues attracted more and more attention since the pesticides were harmful to most living organisms. Regulatory agencies such as Environmental Protection Agency (EPA) and European Chemicals Agency (ECHA) stipulated that a comprehensive pesticides risk assessment was essential and also underscored the application of computation method in evaluating pesticides. The present study aimed to use the Quantitative Structure-Activity Relationship (QSAR) method to establish models for quantitatively and qualitatively predicting the toxicity of pesticide against *Skeletonema costatum*. The regression model was developed using the Genetic Algorithm plus Multiple Linear Regression method and the classification model was established based on the Random Forest algorithm, respectively. Various internal and external validation metrics suggested that the obtained regression model was of good fitness ($R^2=0.722$), robustness ($QLOO2=0.653$) and external predictive ability ($QFn2:0.719-0.776$, $CCC = 0.878$). The classification could correctly predict 79.4% of pesticides in the training set and 69.7% in the validation set. The relatively high sensitivity value of the classification model indicated its good performance in identifying high-toxic pesticides. It could be concluded from the selected modelling descriptors that molecular weight and polarizability impacted the toxicity the most. The atom-type E-state descriptors generally contributed negatively to the pesticide toxicity which verified the negative influence of molecular hydrophilicity. Moreover, the lipophilic, carbon-type, charge related descriptors demonstrated the important influence of lipophilicity and polarity on pesticide toxicity. The models presented in this work could be used to pre-evaluate the toxicity of pesticides within the applicability domain,

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thus focusing resources on the high-toxic pesticides and assessing the environmental risk of pesticides quickly and economically.

Authors: Lu Yang, Cuihong Sang, Yinghuan Wang, Wentao Liu, Weiyu Hao, Jing Chang, Jianzhong Li
Full Source: Chemosphere 2021 Jul 6;285:131456. doi: 10.1016/j.chemosphere.2021.131456.

Transcriptome analysis to elucidate the toxicity mechanisms of fenvalerate, sulfide gatifloxacin, and ridomil on the hepatopancreas of *Procambarus clarkii*

2021-07-10

Most antibiotics, insecticides, and other chemicals used in agricultural and fishery production tend to persist in the environment. Fenvalerate, sulfide gatifloxacin, and ridomil are widely used in aquaculture as antibacterial, antifungal, and antiparasitic drugs; however, their toxicity mechanism remains unclear. Thus, we herein analyzed the effects of these three drugs on the hepatopancreas of *Procambarus clarkii* at the transcriptome level. Twelve normalized cDNA libraries were constructed using RNA extracted from *P. clarkii* after treatment with fenvalerate, sulfide gatifloxacin, or ridomil and from an untreated control group, followed by Kyoto Encyclopedia of Genes and Genomes pathway analysis. In the control vs fenvalerate and control vs sulfide gatifloxacin groups, 14 and seven pathways were significantly enriched, respectively. Further, the effects of fenvalerate and sulfide gatifloxacin were similar on the hepatopancreas of *P. clarkii*. We also found that the expression level of genes encoding senescence marker protein-30 and arylsulfatase A was downregulated in the sulfide gatifloxacin group, indicating that sulfide gatifloxacin accelerated the apoptosis of hepatopancreatocytes. The expression level of major facilitator superfamily domain containing 10 was downregulated, implying that it interferes with the ability of the hepatopancreas to metabolize drugs. Interestingly, we found that Niemann pick type C1 and glucosylceramidase- β potentially interact with each other, consequently decreasing the antioxidant capacity of *P. clarkii* hepatopancreas. In the fenvalerate group, the downregulation of the expression level of xanthine dehydrogenase indicated that fenvalerate affected the immune system of *P. clarkii*; moreover, the upregulation of the expression level of pancreatitis-associated protein-2 and cathepsin C indicated that fenvalerate caused possible inflammatory pathological injury to *P. clarkii* hepatopancreas. In the ridomil group, no pathway was significantly enriched. In total, 21 genes showed significant differences in all three groups. To conclude, although there appears to be some overlap

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in the toxicity mechanisms of fenvalerate, sulfide gatifloxacin, and ridomil, further studies are warranted.

Authors: Ruze Xu, Ruizhou Zheng, Yali Wang, Rongrong Ma, Guixiang Tong, Xinxian Wei, Dongyue Feng, Kun Hu

Full Source: Fish & shellfish immunology 2021 Jul 10;116:140-149. doi: 10.1016/j.fsi.2021.07.004.

ENVIRONMENTAL RESEARCH

Mutagenicity, health risk, and disease burden of exposure to organic micropollutants in water from a drinking water treatment plant in the Yangtze River Delta, China

2021-09-15

A wide variety of organic micropollutants in drinking water pose a serious threat to human health. This study was aimed to reveal the characteristics of organic micropollution profiles in water from a drinking water treatment plant (DWTP) in the Yangtze River Delta, China and investigate the mutagenicity, health risk and disease burden through mixed exposure to micropollutants in water. The presence of organic micropollutants in seven categories in organic extracts (OEs) of water from the DWTP was determined, and Ames test was conducted to test the mutagenic effect of OEs. Meanwhile, health risk of exposure to organic micropollutants in finished water through three exposure routes (ingestion, dermal absorption and inhalation) was assessed with the method proposed by U.S. EPA, and disability-adjusted life years (DALYs) were combined to estimate the disease burden of cancer based on the carcinogenic risk (CR) assessment. The results showed that 28 organic micropollutants were detected in the raw and finished water at total concentrations of 967.28 ng/L and 1073.45 ng/L, respectively, of which phthalate esters (PAEs) were the dominant category (95.79% in the raw water and 96.61% in the finished water). Although the results of the Ames test for OEs were negative and the non-carcinogenic hazard index of the organic micropollutants in the finished water was less than 1 in all age groups, the total CR was 2.17×10^{-5} , higher than the negligible risk level (1.00×10^{-6}). The total DALYs caused by the organic micropollutants in the finished water was 2945.59 person-years, and the average individual DALYs was 2.21×10^{-6} per person-year (ppy), which was 2.21 times the reference risk level (1.00×10^{-6} ppy) defined by the WHO. Exposure to nitrosamines (NAms) was the major contributor to the total CR (92.06%) and average individual DALYs (94.58%). This study demonstrated that despite the

A wide variety of organic micropollutants in drinking water pose a serious threat to human health.

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negative result of the mutagenicity test with TA98 and TA100 strains, the health risk of exposure to organic micropollutants in drinking water should not be neglected.

Authors: Panqi Xue, Yameng Zhao, Danyang Zhao, Meina Chi, Yuanyuan Yin, Yanan Xuan, Xia Wang

Full Source: Ecotoxicology and environmental safety 2021 Sep 15;221:112421. doi: 10.1016/j.ecoenv.2021.112421.

Environmental and Health Risks of Pesticide Use in Ethiopia

2021-05-28

Background: There are frequent reports of unsafe pesticide use in many parts of Africa. Ethiopia is the second most populous nation in Africa with around 80% of the population still depending on agriculture which intensively uses pesticides. A number of studies have examined pesticide-related health and environmental risks in Ethiopia. However, most of these studies have been small in scale and it is therefore challenging to get a general overview of the extent of health risks and level of environmental contamination in the country.

Objectives: The aim of the present study was to synthesize and summarize contemporary knowledge on pesticide-related risks and relevant gaps in Ethiopia.

Methods: An electronic database search and gathering of grey literature were done to collect information on the risks of pesticide use in Ethiopia. The electronic search was conducted using MEDLINE (via PubMed) without any publication date or language specifications. The Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) checklist was used as guide in the creation of this review.

Discussion: A synthesis of the reviewed studies showed evidence of health risks due to occupational pesticide exposure, surface water pollution with pesticides that could cause chronic health risks to the public, evidence of pesticide contamination of the environment (e.g., soil organisms, fish, bee colonies and wildlife) and local as well as international consumer risks due to pesticide residues in food items. In addition, there have been frequent reports of health and environmental hazards in association with cut-flower farms. There is also evidence of direct use of DDT (dichlorodiphenyltrichloroethane) on food crops and detection of DDT residues in surface water, soil and human breast milk. Those reported risks might be due to lack of knowledge among farm workers, negligence of farm owners, absence of post-registration monitoring systems and poor implementation of both national and international regulations in Ethiopia due to poor institutional capacity. Conclusions: The

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health and environmental risks of inappropriate use of pesticides requires action by all concerned bodies. Improved institutional arrangements for enforcement of regulations, awareness and further intervention studies could lessen the high risks of pesticide misuse.

Competing interests: The authors declare no competing financial interests.

Authors: Beyene Negatu, Sisay Dugassa, Yalemshay Mekonnen

Full Source: Journal of health & pollution 2021 May 28;11(30):210601. doi:

10.5696/2156-9614-11.30.210601.

How can vegetation protect us from air pollution? A critical review on green spaces' mitigation abilities for air-borne particles from a public health perspective - with implications for urban planning

2021-06-24

Air pollution causes the largest death toll among environmental risks globally, but interventions to purify ambient air remain inadequate. Vegetation and green spaces have shown reductive effects on air-borne pollutants concentrations, especially of particulate matter (PM). Guidance on green space utilisation for air quality control remains scarce, however, as does its application in practise. To strengthen the foundation for research and interventions, we undertook a critical review of the state of science from a public health perspective. We used inter-disciplinary search strategies for published reviews on green spaces and air pollution in key scientific databases. Using the PRISMA checklist, we systematically identified reviews with quantitative analyses. For each of the presented PM mitigation mechanisms, we conducted additional searches focused on the most recent articles published between 2016 and early 2021. The included reviews differentiate three mitigation mechanisms of green spaces for PM: deposition, dispersion and modification. The most studied mechanism is deposition, particularly measures of mass and settling velocity of PM on plant leaves. We consolidate how green space setups differ by scale and context in their potentials to reduce peak exposures, stationary (point) or mobile (line) pollution sources, and the potentially most harmful PM components. The assessed findings suggest diverse optimisation options for green space interventions, particularly concerning plant selection, spatial setup, ventilation and maintenance - all alongside the consideration of supplementary vegetation effects like on temperature or water. Green spaces' reductive effects on air-borne PM concentrations are considerable, multi-mechanistic and varied by scale, context and vegetation characteristics. Such effect-modifying factors must be considered when rethinking public space design, as accelerated by the

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COVID-19 pandemic. Weak linkages amid involved disciplines motivate the development of a research framework to strengthen health-oriented guidance. We conclude on an urgent need for an integrated and risk-based approach to PM mitigation through green space interventions.

Authors: Arnt Diener, Pierpaolo Mudu

Full Source: The Science of the total environment 2021 Jun 24;796:148605.

doi: 10.1016/j.scitotenv.2021.148605.

OCCUPATIONAL

Occupational contact dermatitis in painters and varnishers: data from the Information Network of Departments of Dermatology (IVDK), 2000 to 2019

2021-07-14

Introduction: Painters and varnishers ("painters") are exposed to various contact allergens and skin irritants, and therefore, at risk to develop occupational dermatitis (OD). Objective: To describe the spectrum of occupational sensitizations in painters and revise corresponding current patch test recommendations.

Patients and methods: Retrospective analysis of Information Network of Departments of Dermatology (IVDK) data from 2000 to 2019 with focus on male painters with OD, aged 20-59 years (n=557) in comparison to age-matched male painters without OD (n=422) and male OD patients that have had never worked as painters (n=13862).

Results: Male painters with OD have a significantly higher rate of allergic contact dermatitis and face dermatitis than male patients with OD working in other professions. Positive patch tests to epoxy resin, methylisothiazolinone (MI), and methylchloroisothiazolinone (MCI)/MI were significantly more frequent in painters with OD than in the other groups. Epoxy resin sensitization was significantly associated with face dermatitis.

Conclusions: Epoxy resin, MI and MCI/MI represent most important occupational sensitizers in painters. In addition to baseline, resins and glues, and industrial biocides series, patients' own workplace materials should be tested in painters with suspected OD. This article is protected by copyright. All rights reserved.

Authors: Steffen Schubert, Andrea Bauer, Uwe Hillen, Thomas Werfel, Johannes Geier, Richard Brans, IVDK, Aachen J M Baron, Aarau J Grabbe, Augsburg A Ludwig, K Siedlecki, Bad Reichenhall K Strom, Basel A Bircher, K Scherer, K Hartmann, Berlin B Frank, B Tebbe, R Treudler, Berlin Bwk

Introduction: Painters and varnishers ("painters") are exposed to various contact allergens and skin irritants, and therefore, at risk to develop occupational dermatitis (OD).

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A Köhler, Berlin Charité T Zuberbier, M Worm, Bern D Simon, Bielefeld I Effendy, Bochum Ch Szliska, M Straube, H Dickel, Bochum Bgfa M Fartasch, Bremen D Meyersburg, N Patsinakidis, Buxtehude P Große-Hüttmann, P Hausenblas, Dermatologikum V Martin, K Reich, K Breuer, D Vieluf, Dessau A Jung, U Lippert, Dortmund P J Frosch, B Mydlach, C Pirker, R Herbst, K Kügler, U Beiteke, Dresden G Richter, R Aschoff, P Spornraft-Ragaller, Dresden Friedrichst, A Koch, Erlangen M Fartasch, M Hertl, V Mahler, N Wagner, Essen J Dissemond, Falkenstein H Schwantes, D Vieluf, M Fischer, M Gina, Freudenberg Ch Szliska, Gera J Meyer, H Grunwald-Delitz, M Kaatz, Graz W Aberer, B Kränke, Greifswald M Jünger, Göttingen Th Fuchs, T Buhl, Halle G Gaber, D Lübbe, B Kreft, Hamburg M Kiehn, R Weißbecher, E Coors, J Witte, Hamburg Buk K Breuer, U Seemann, C Schröder-Kraft, Hannover T Schaefer, A Kapp, Heidelberg A Schulze-Dirks, M Hartmann, U Jappe, M Hartmann, K Schäkel, Heidelberg Aks H Dickel, T L Diepgen, E Weisshaar, Heilbronn H Löffler, P Amann, Homburg Saar P Koch, C Pföhler, Jena W Wigger-Alberti, M Kaatz, S Schliemann, Kiel J Brasch, Krefeld A Wallerand, M Lilie, S Wassilew, Lausanne P Spring, C Curdin, Leipzig R Treudler, Linz I Angelova-Fischer, Lippe Detmold St Nestoris, Lübeck J Grabbe, I Shimanovich, U Jappe, K Hartmann, À Recke, Mainz D Becker, Mannheim Ch Bayerl, D Booken, C-D Klemke, W Ludwig-Peitsch, A Schmieder, Marburg I Effendy, H Löffler, M Hertl, W Pfützner, Minden J Hoffmann, R Stadler, München Lmu T Oppel, B Przybilla, P Thomas, T Schuh, R Eben, S Molin, F Rueff, München Schwabing M Agathos, K Ramrath, M Georgi, K Ramrath, G Isbary, München Tu J Rakoski, U Darsow, T Biedermann, K Brockow, Münster B Hellweg, R Brehler, M Behring, Nürnberg I Müller, D Debus, A Bachtler, K Ertner, V Baur, Oldenburg M Padeken, O Kautz, U Raap, Osnabrück W Uter, S M John, H J Schwanitz, N Schürer, H Dickel, Ch Skudlik, S M John, Prager Und Partner V Martin, W Prager, Rostock H Heise, J Trcka, Stuttgart J Rieker-Schwiebacher, Tobelbad D Wilfinger, Tübingen G Lischka, M Röcken, T Biedermann, J Fischer, S Forchhammer, Ulm H Gall, G Staib, P Gottlöber, Ulm Bwk H Pillekamp, Ulm Univ-Klinik J Weiss, Würzburg J Arnold, A Trautmann, Zwickau B Knopf, D Teubner, D Mechtel, Zürich B Ballmer-Weber, A Navarini, S Micaletto, C Lang
Full Source: Contact dermatitis 2021 Jul 14. doi: 10.1111/cod.13935.

Urinary bisphenol levels in plastic industry workers

2021-07-12

Bisphenol A (BPA) is a known endocrine disruptor compound that is widely applied as a monomer base in polycarbonate plastics and as a binding agent in several epoxy resins. Plastic industry workers have usually heavier and prolonged exposures to BPA. Hence, the present work aims to assess

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the levels of BPA and their analogs (S, F, B, AF, Z, E, and AP) in 170 urine samples from a cross-sectional study of workers from a plastic industry located in north Constantine (Algeria). This work was complemented with a questionnaire about sexual functions and evaluation of sexual hormone levels. The results showed a stable presence of BPA (average of 3.24 µg/L), accounting for more than 90% of the total BPs. Of the remaining BP analogs, only trace amounts of BPB were detected in three samples (average of 2.73 µg/L). Significant associations with BPA urinary levels were noted with age ($p = 0.006$), occupational level of exposure ($p = 0.023$), and years of experience ($p = 0.001$).

Authors: Iméne Rebai, José O Fernandes, Mohamed Azzouz, Karima Benmohammed, Ghania Bader, Karima Benmbarek, Sara C Cunha
Full Source: Environmental research 2021 Jul 12;202:111666. doi: 10.1016/j.envres.2021.111666.

PHARMACEUTICAL/TOXICOLOGY

Exposome of attention deficit hyperactivity disorder in Taiwanese children: exploring risks of endocrine-disrupting chemicals

2021-07-15

Background: Attention-deficit hyperactivity disorder (ADHD) is diagnosed in ~7% of school-aged children. The role of endocrine-disrupting chemicals (EDC) and oxidative stress in ADHD etiology are not clear. Objective: Assessment of the associations between simultaneous exposure to multiple compounds and ADHD in children. Methods: The case-control study included 76 clinically diagnosed ADHD cases and 98 controls, aged 4-15 years old. Concentrations quartiles of urinary metabolites of acrylamide, acrolein, nonylphenol, phthalates, and organophosphate pesticides and biomarkers of oxidative stress were used to fit logistic regressions for each compound and weighted quantiles sum (WQS) regression for the mixture. Results: Positive dose-response relationships with ADHD were observed for 4-hydroxy-2-nonenal-mercaptopuric acid (HNE-MA) (odds ratio(OR)Q4 = 3.73, 95%CI [1.32, 11.04], ptrend = 0.003), dimethyl phosphate (DMP) (ORQ4 = 4.04, 95%CI [1.34, 12.94], ptrend = 0.014) and diethyl phosphate (ORQ4 = 2.61, 95%CI = [0.93, 7.66], ptrend = 0.030), and for the mixture of compounds (ORWQS = 3.82, 95%CI = [1.78, 8.19]) with the main contributions from HNE-MA (28.9%) and DMP (18.4%).

Background: Attention-deficit hyperactivity disorder (ADHD) is diagnosed in ~7% of school-aged children.

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Conclusions: The dose-response relationship suggests enhanced susceptibility to EDC burden in children even at lower levels, whereas the main risk is likely from organophosphate pesticides. HNE-MA is recommended as a sensitive biomarker of lipid peroxidation in the further elucidation of the oxidative stress role in ADHD etiology.

Authors: Alexander Waits, Chia-Huang Chang, Ching-Jung Yu, Jung-Chieh Du, Hsien-Chih Chiou, Jia-Woei Hou, Winnie Yang, Hsin-Chang Chen, Ying-Sheue Chen, Betau Hwang, Mei-Lien Chen

Full Source: Journal of exposure science & environmental epidemiology 2021 Jul 15. doi: 10.1038/s41370-021-00370-0.