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REVIEW COMMENT FOR PUBLISHED ARTICLE

Comment on "A new approach to stabilization of calcareous dune sand" [Int. J. Environ. Sci. Technol. 19, 3581–3592 (2022)]

M. D. Vaverková[1,2] · **B. C. O'Kelly**[3]

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The Discussers read with interest the paper by Ghadr et al. (2022) (the Authors); the research topic being particularly important for various regions of the world regarding the main goals of dust suppression and wind-driven soil erosion control. In their paper, the Authors proposed a new approach for stabilization of dune sand deposits, whereby ground rubber (GR) material and colloidal nano-silica (NS) hydrosol are mixed with the sand, such that a thin, porous and lightweight crustal layer could be formed on the sand deposit for limiting the dust deflation. The Authors report that this GR–NS sand treatment preserves, and may even enhance, the sand's open pore structure, such that the engineered crustal layer would not disrupt the soil's biogeochemical cycles. For optimal strength and post-peak performance, the Authors recommend the additions of 5 wt.% GR and 15–25% NS to the test sand (investigating calcareous Urmia Lake sand), whose constituent particles ranged 0.08–3.2 mm in size, as evident from Fig. 2 of their paper.

In geotechnical engineering applications, waste-tire-derived aggregates (TDAs), including GR, have merits as alternatives or partial replacements for natural soils and aggregates; for instance (i) as additives for the stabilization of expansive soils, (ii) for construction of highway embankments and pavements, (iii) as lightweight backfills to bridge abutments and retaining walls, (iv) for improving the liquefaction resistance of silty sand (e.g., see Ghadr et al. 2021; Khatami et al. 2020; Raeesi et al. 2020; Shahrokhi-Shahraki et al. 2020 and Soltani et al. 2019, 2020, 2021, 2022a, b). Notwithstanding their engineering performance benefits demonstrated for the above-mentioned applications, when considering the widespread use of TDA/GR material in the stabilization of the surface layer for dune sand deposits (as proposed by the Authors), it is the Discussers' perspective that the environmental and ecotoxicological concerns are to the fore. While on the one hand the Authors say that "*both NS and GR count as eco-friendly* (page 2 of 11 of their paper)", they subsequently describe the GR additive as "*a complex mixture of polybutadiene, polyisoprene, elastomers, and styrene-butadiene compounds*" (page 4 of 12) and later they acknowledge that "*waste tire in soil is a potential source of groundwater*

Editorial responsibility: Samareh Mirkia.

✉ B. C. O'Kelly
bokelly@tcd.ie

[1] Department of Applied and Landscape Ecology, Faculty of AgriSciences, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

[2] Institute of Civil Engineering, Warsaw University of Life Sciences, Nowoursynowska 159, 02 776 Warsaw, Poland

[3] Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Dublin D02 PN40, Ireland

contamination, and a potential cause of increasing chromium, iron, copper, nickel, and zinc ionic load in clayey soils, and to a lesser extent in granular soils (page 11 of 12 of their paper)." As elaborated in the following paragraphs, from the Discussers' perspective, there are various environmental concerns regarding the proposed GR–NS-treatment application for crustal layer stabilization of dune sand deposits.

Firstly, there is the potential toxicity of leachates containing heavy metals and other chemicals common in TDA/GR materials, as well as the microplastic particles (Goli et al. 2022; O'Kelly et al. 2022) derived from weathering and physical breakdown of the GR additive in-situ, as sources of contamination to the terrestrial environment. Tallec et al. (2022) emphasized that the use of rubber-based products (e.g., crumb rubber granulates) can induce "rubber contamination" by the release of micro-rubber and/or constitutive compounds (added during manufacturing processes and subsequently) leached out by the action of water. For instance, according to Azizian et al. (2003), crumb-rubber asphalt concrete leachates contain a mixture of organic and metallic contaminants, with benzothiazole, 2(3H)-benzothiazolone (organic compounds used in tire-rubber manufacturing) and the metals mercury and aluminum leached in potentially harmful concentrations (exceeding toxic concentrations for aquatic toxicity tests). Halsband et al. (2020) reported that a cocktail of organic additives and metals readily leached from crumb rubber (into seawater), with the most abundant leachate components being benzothiazole, zinc, iron and cobalt, as well as detectable levels of organic pollutants, such as polycyclic aromatic hydrocarbons (PAHs) and phenolic compounds. From the studies by Šourková et al. (2021a, 2021b), it is evident that leachates from waste tire fractions are phytotoxic to highly phytotoxic for higher plants, and based on their findings, it could be concluded that tire-derived materials are not recommended for usage as granulate in direct contact with the environment. Leifheit et al. (2021) studied the effects of tire particles at environmentally relevant concentrations on plant growth, soil pH and key ecosystem processes of litter decomposition and soil respiration. Addition of tire particles was found to negatively affect shoot and root growth at low concentrations and also altered a number of biogeochemical soil parameters that can further effect plant performance. Research by Skoczyńska et al. (2021) confirmed that proper toxicological risk assessment of recycled rubber used cannot be based on a limited set of target analytes alone, while ignoring many other hazardous compounds present in GR. Their obtained results emphasize the need for expanding the list of target compounds analyzed in GR.

Secondly, considering the open-pore structure produced for the GR–NS-treated crustal sand layer (as described by the Authors), the Discussers would have concerns on the impact to ambient air quality arising from the GR additive's exposure to air, ultraviolet-light and heat (i.e., leading to potential release of volatile and semi-volatile organic compounds (Liu et al. 2000)). Thirdly, addition of 5 wt.% GR material (of black color) to the surface layer of calcareous dune-sand deposits (as the Authors propose in their GR–NS treatment for forming a stabilized crustal sand layer) would produce an expected (negative) visual impact on the landscape.

Hence, from the Discussers' perspectives, comprehensive studies on these environmental aspects are deemed essential before countenancing the field application of the proposed GR–NS-treatment approach for crustal layer stabilization of dune sand deposits, in general, and particularly for the calcareous dune sands (of the Urmia Lake area). The extent of leachate and mutual relations in different environments that may result from the use of tire-derived products in civil engineering applications is not fully quantified. From the Discussers' experience, GR-additive leachate studies should be conducted under different environmental conditions (pH and/or liquid to solid ratios). We therefore believe that further comprehensive studies are needed in these areas.

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References

Azizian MF, Nelson PO, Thayumanavan P, Williamson KJ (2003) Environmental impact of highway construction and repair materials on surface and ground waters: case study: crumb rubber asphalt concrete. Waste Manage 23(8):719–728. https://doi.org/10.1016/S0956-053X(03)00024-2

Ghadr S, Samadzadeh A, Bahadori H, O'Kelly BC, Assadi-Langroudi A (2021) Liquefaction resistance of silty sand with ground rubber additive. Int J Geomech 21(6):04021076. https://doi.org/10.1061/(ASCE)GM.1943-5622.0002002

Ghadr S, Assadi-Langroudi A, Hung C (2022) A new approach to stabilization of calcareous dune sand. Int J Environ Sci Technol 19:3581–3592. https://doi.org/10.1007/s13762-021-03407-x

Goli VSNS, Paleologos EK, Farid A et al (2022) Extraction, characterisation and remediation of microplastics from organic solid matrices. Environ Geotech. https://doi.org/10.1680/jenge.21.00072 (In Press)

Halsband C, Sørensen L, Booth AM, Herzke D (2020) Car tire crumb rubber: does leaching produce a toxic chemical cocktail in coastal marine systems? Front Environ Sci 8:125. https://doi.org/10.3389/fenvs.2020.00125

Khatami H, Deng A, Jaksa M (2020) Passive arching in rubberized sand backfills. Can Geotech J 57(4):549–567. https://doi.org/10.1139/cgj-2018-0672

Leifheit EF, Kissener HL, Faltin E, Ryo M, Rillig MC (2021) Tire abrasion particles negatively affect plant growth even at low concentrations and alter soil biogeochemical cycling. Soil Ecol Lett. https://doi.org/10.1007/s42832-021-0114-2 (In Press)

Liu HS, Mead JL, Stacer RG (2000) Environmental effects of recycled rubber in light-fill applications. Rubber Chem Technol 73(3):551–564. https://doi.org/10.5254/1.3547605

O'Kelly BC, El-Zein A, Liu X et al (2022) Microplastics in soils: an environmental geotechnics perspective. Environ Geotech 8(8):586–618. https://doi.org/10.1680/jenge.20.00179

Raeesi R, Soltani A, King R, Disfani MM (2020) Field performance monitoring of waste tire-based permeable pavements. Transp Geotech 24:100384. https://doi.org/10.1016/j.trgeo.2020.100384

Shahrokhi-Shahraki R, Kwon PS, Park J, O'Kelly BC, Rezania S (2020) BTEX and heavy metals removal using pulverized waste tires in engineered fill materials. Chemosphere 242:125281. https://doi.org/10.1016/j.chemosphere.2019.125281

Skoczyńska E, Leonards PEG, Llompart M, de Boer J (2021) Analysis of recycled rubber: development of an analytical method and determination of polycyclic aromatic hydrocarbons and heterocyclic aromatic compounds in rubber matrices. Chemosphere 276:130076. https://doi.org/10.1016/j.chemosphere.2021.130076

Soltani A, Deng A, Taheri A, O'Kelly BC (2019) Engineering reactive clay systems by ground rubber replacement and polyacrylamide treatment. Polymers 11(10):1675. https://doi.org/10.3390/polym11101675

Soltani A, Taheri A, Deng A, O'Kelly BC (2020) Improved geotechnical behavior of an expansive soil amended with tire-derived aggregates having different gradations. Minerals 10(10):923. https://doi.org/10.3390/min10100923

Soltani A, Azimi M, O'Kelly BC (2021) Modeling the compaction characteristics of fine-grained soils blended with tire-derived aggregates. Sustainability 13(14):7737. https://doi.org/10.3390/su13147737

Soltani A, Nguyen DTD, O'Kelly BC, Taheri A (2022a) Predicting the compactability of artificially cemented fine-grained soils blended with waste-tire-derived aggregates. Transp Infrastruct Geotechnol. https://doi.org/10.1007/s40515-021-00214-2 (In Press)

Soltani A, Taheri A, Deng A, O'Kelly BC (2022b) Stabilization of a highly expansive soil using waste-tire-derived aggregates and lime treatment. Case Constr Mat 16:e01133. https://doi.org/10.1016/j.cscm.2022.e01133

Šourková M, Adamcová D, Winkler J, Vaverková MD (2021a) Phytotoxicity of tires evaluated in simulated conditions. Environments 8:49. https://doi.org/10.3390/environments8060049

Šourková M, Adamcová D, Vaverková MD (2021b) The influence of microplastics from ground tyres on the acute, subchronical toxicity and microbial respiration of soil. Environments 8:128. https://doi.org/10.3390/environments8110128

Tallec K, Huvet A, Yeuc'h V, Le Goïc N, Paul-Pont I (2022) Chemical effects of different types of rubber-based products on early life stages of pacific oyster *Crassostrea gigas*. J Hazard Mater 427:127883. https://doi.org/10.1016/j.jhazmat.2021.127883