Microplastics pollution pathways to groundwater in India

Plastics are typically organic polymers of high molecular mass, but they often contain other toxic substances which may disturb the ecological resilience. Due to the high volume of plastics being used, microplastics are emerging as pollutants with their small particles size (<5 mm), which is impacting not only the terrestrial and marine ecosystems, but also the freshwater environs[1–3]. In addition to being present in different surface water bodies, microplastics have recently been reported in groundwater resources in India, which is normally being used for drinking purpose in Chennai, Tamil Nadu[1]. Ganesan *et al.*[1] reported plastic debris less than 5 mm as microplastic at the target zone (below the ground surface). Furthermore, they categorized microplastics as primary and secondary types[1]. The primary and secondary microplastic types are categorized based on their production and degradation[4]. The microplastics content in groundwater was analysed using a number of samples to examine their actual concentration[1]. It was concluded that the microplastics content in groundwater was due to anthropogenic activities such as agricultural farming, fishing, wastewater treatment works, household activities, etc.[1].

Ganesan *et al.*[1] used cellulose nitrate filter paper (0.45 μm) equipped with vacuum filtration for microplastics extraction from the collected water samples. McCormick *et al.*[5] used the Neuston net (333 μm) for extraction of microplastics from surface water in Chicago River, USA. Subsequently, scanning electron microscope equipped with energy-dispersive X-rays was used to identify shape, colour and count of the microplastics, and also to determine the associated heavy metals adsorbed onto their surface[5]. Fibrous and fragment-shaped microplastics were reported in water samples of Chennai, and polymeric characteristics were determined using Fourier transform infrared spectroscopy for a better understanding of the potential sources of microplastics[6].

Furthermore, microplastics in groundwater due to contamination of the aquifer system, which is extensively used for drinking purpose across the globe, are being contributed mainly through wastewater treatment plants, septic effluent, etc. The transport and reaction of microplastics have also been found in the aquifer system. Microplastics act as a vector for transporting other contaminants, such as heavy metals, trace metals, etc. to both terrestrial and aquatic environs. Ganesan *et al.*[1] also confirmed the transport of heavy metals through adsorption onto the surface of microplastics and potential anthropogenic sources in groundwater at Pallipattu, Pallikaranai and Kovur, along with the presence of essential elements such as carbon, oxygen, sodium, magnesium, aluminium, silicon, chloride, potassium and calcium in all three categories of water (surface water, groundwater and commercial drinking water).

Microplastics pollution is also reported in sediments of lakes, estuaries and coastal beaches in India[3,6]. Apart from sediments, limited studies have been conducted so far on samples from freshwater ecosystems[2] and groundwater[1]. However, several natural ecosystems, such as mangroves, coastal and freshwater wetlands, aquifer systems, springs, lakes, agricultural soil, surface water, etc. need to be studied to determine the extent of microplastics pollution and the potential strategies for remediation. The accumulation of microplastics mainly in sediments and water samples in various ecosystems has led to banning the use of plastics across the globe, including India. The Government of India has affirmatively banned plastic bags (<50 μm thickness) since 2016. The National Green Tribunal has prohibited disposable plastics since 2017. Assessing abundance and distribution of microplastics has significant potential for future environmental pollution-based research, disruption in ecosystem services, and ecological stability and resilience. In comparison, the exposure of microplastics to the food chain, along with human beings, has still been unexplored in the Indian ecosystem. Therefore, the recent study by Ganesan *et al.*[1] on microplastics in drinking water and groundwater would be a new discourse regarding nanoplastics from sediments, groundwater and surface-water systems, along with transfer into the food chain. Policies for proper implementation of solid/liquid waste management system need to be reinforced to prevent the transport of microplastics into the groundwater and minimize their presence in sediments, aquatic organisms and human beings.

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Discovery of fossil dragonfly from India – a rejoinder

Insect fossil records are relatively rare in India. Diverse arthropod taxa with more than 55 families and 100 species, except Odonata (dragonflies and damselflies) were reported from the 50–52 million-year-old (Cenozoic) amber Cambay Shale, Gujarat[1]. However, over 50 species of much older Odonata fossils have been discovered from geographically closer mid-Cretaceous Burmese amber (circa 100 million years)[2]. Modern Odonata appeared during the Triassic with

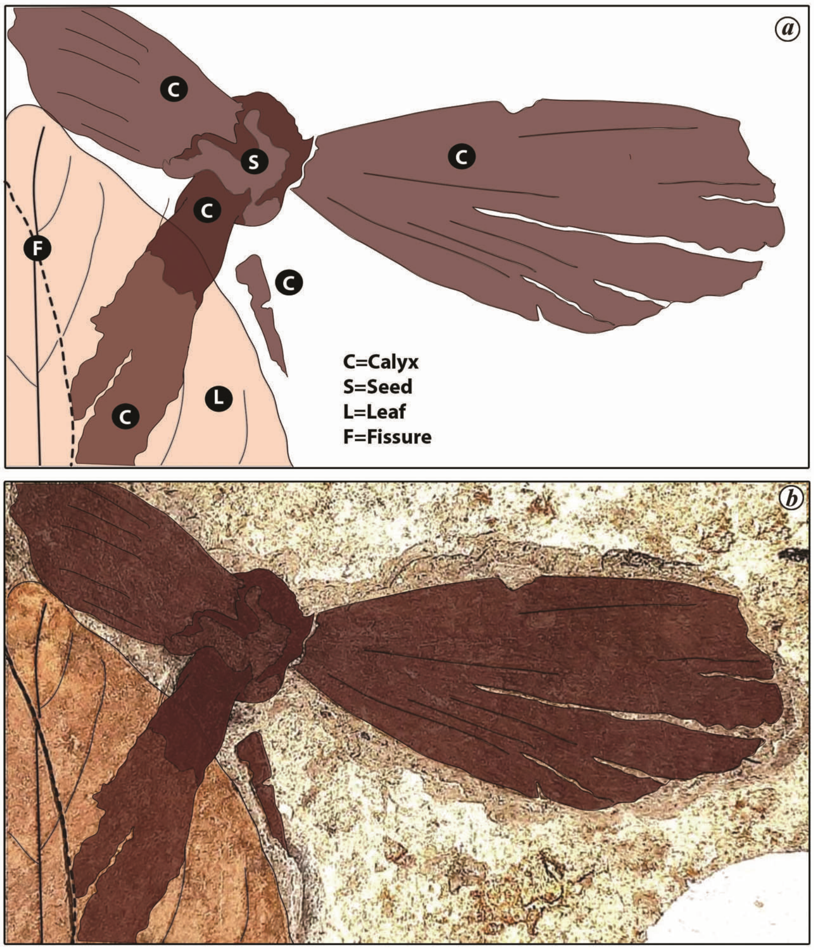

Figure 1. ***a***, Drawing of the fossil. ***b***, Drawing superimposed on the fossil image.

Anisoptera originating in the Jurassic and based on the available fossil records, the minimum age for different crown groups has been calibrated[3]. The order Odonata is paleopterous (i.e. unable to fold wings over the abdomen at rest) with direct flight muscles and is distinguished by several plesiomorphic characters, including distinct nodus and pterostigma in the wings[4]. The evolutionary antiquity of the taxa has been a fascination for biologists and palaeontologists to understand the past history of the earth.

This journal has recently reported the discovery of a fossil dragonfly from the late Neogene sediments of the Chotanagpur plateau, India[5]. The image of the fossil was also featured on the coverpage. Based on the published description of the fossil photograph and drawing, we propose an alternative interpretation of the data and contest the claim of discovery of the dragonfly fossil.

The fossil reported from Chotanagpur plateau was identified as that of a dragonfly (order Odonata). The authors describe the characters observed in the fossil such as four wings, nodus, pterostigma, wing venation, compound eyes, thorax, abdomen and terminalia and a drawing was presented. A critical examination of image of the fossil and the illustration does not support the claim. In the fossil, no ‘compound eyes’, ‘thorax’, ‘wings’, ‘nodus’, ‘pterostigma’, ‘abdomen’, ‘terminalia’ and ‘legs’ are discernable. In the illustration, the ‘compound’ eyes are wrongly placed over the thorax and legs are shown attached to the abdomen. The ‘fore and hind wings’ are indistinct and bilaterally asymmetric. There are no characters which suggest that the fossil belongs to a dragonfly (e.g. dissimilar fore and hind wing with distinct nodus and pterostigma), or insect (e.g. body divided into head, thorax and abdomen), or even an arthropod (e.g. segmented body and appendages). The authors also mentioned that the fossil resembles extant *Libellua depressa* Linnaeus, 1758 (Anisoptera: Libellulidae) without providing any supporting evidence for identification of the family, genus or species. Hence, we refute the claim of discovery of the fossil dragonfly and propose an alternative interpretation of the data.

The fossil dragonfly is redrawn and presented with labels (Figure 1 *a* and *b*). We interpret that the fossil does not belongs to any insect but the winged seed of tropical low-land tree family Dipterocarpaceae, most probably that of *Shorea* sp. which was widespread during the Neogene in South Asia[6]. The ‘wings of dragonfly’ are actually the wing-like enlarged calyx lobe with parallel venation which is similar to the fossil calyx lobe of *Shorea* sp.[6] and also present in the extant *Shorea* sp. Interestingly and probably overlooked by the authors[5], a clear leaf impression is visible in the published fossil image which is superimposed over the 'dragonfly abdomen'. The 'abdomen' is actually the third calyx of the seed (Figure 1) and the elliptic shape of the leaf is also surprisingly similar to that of *Shorea* sp. of the Neogene[6]. We therefore propose that the fossil belongs to that of a compressed seed of Dipterocarpaceae. The asymmetrical wings and abdomen of 'fossil dragonfly' are naturally asymmetrical calyx lobe, and the 'thorax and head' of the dragonfly are the seed part of *Shorea* sp. The 'leg' may be a fragment of the calyx. Since there is the possibility of an alternative interpretation for the fossil, it may be further studied with high-resolution imaging to unequivocally establish the correct identity.

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NEWS

France Honours Rohini Godbole with 'Ordre National du Mérite'

Prof. Rohini Godbole, a theoretical particle physicist, currently an Honorary Professor at the Centre for High Energy Physics, Indian Institute of Science, Bengaluru, has been awarded the National Order of Merit, one of the highest French civilian distinctions. Making a reference to her internationally acclaimed contributions to particle physics spanning more than four decades that led her to successfully set up strong and highly successful scientific collaborations between France and India, the award also highlights the major role Rohini Godbole has played in promoting the cause of women in science and her communication skills that have helped in a better understanding of the physical sciences in India.

A fellow of all the three Science Academies of India and also a fellow of The World Academy of Sciences (TWAS), and a founder-chair of the Panel for Women in Science of the Indian Academy of Sciences, her recent honours include Padma Shri from the Government of India and the R. D. Birla Award of the Indian Physics Association for outstanding contributions to Physics. Rohini Godbole's current research interests focus on Higgs Phenomenology, Supersymmetry, Dark Matter Searches and related aspects of the Physics beyond the Standard Model, and Next Generation Colliders. She was also involved in the draft formulation of Science, Technology and Innovation Policy (STIP) 2020, as a chair of the Committee on Equity and Inclusion that has suggested several important measures for tackling the current inequitable participation in STEM with respect to gender, social, regional and economic diversity.

Other recent recipients of the 'Ordre National du Mérite' in the Indian scientific community include Satyajit Mayor, Director of the National Centre for Biological Sciences, Bengaluru and A. S. Kiran Kumar, former chairman of the Indian Space Research Organisation.