Fit for the future of our railways:
cleaner, safer and longer-life track ballast

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The British railway network has over 20,000 miles of track (7), the vast majority of which uses ballast. Once ballast becomes saturated with contaminants such as diesel, it can no longer adequately drain and would require maintenance and replacement. Track ballast can have a large carbon footprint through quarrying and transport, and presents human risk through operative exposure to live railway. This poster presents a novel approach to lengthening the life of track ballast, and lowering contamination levels through the prescribed addition of bioremediation agents and biosurfactants in ballast preparations prior to installation on track.

Track ballast contamination: why does it matter?

Rail ballast is used on permanent way throughout the world, providing track bed and drainage. The ballast is typically made up of angular aggregate of 30 to 50 mm, and produced from naturally durable and hard rocks such as granite.

Although incredibly adept in supporting high-traffic track, frequent maintenance is needed. This includes periodic cleaning involving complete removal of the ballast. Diesel and other contaminants accumulate in the voids of the ballast, reducing drainage potential. Ballast failure can be catastrophic. Fine sediment accumulated in the ballast becomes trapped, and as a result the track is susceptible to subsidence, presenting risk of derailment (11).

A novel theoretical approach for in-situ ballast cleaning and conclusions based on calculations are explored.

Fig. 1: example of diesel contaminated railway ballast

The most common ballast contaminant is diesel, especially at stations and other stopping points (1). Diesel trains are still used on a large proportion of the UK rail network.

Safety

Drainage defect is a significant cause of fatal rail crashes, for example in the Carmont rail crash in 2020 which resulted in three fatalities (10). Improvements to ballast maintenance may lower the risk of future accidents.

Fig. 2: View of the Carmont rail crash (10)

Maintenance activities expose railway workers to live railway. Reduced maintenance would reduce railway fatalities.

2 million tonnes of ballast is purchased by Network Rail per year (4)

Ballast requires removal for cleaning every 10 years (5)

Whole life carbon of ballasted track is 18 % more than unballasted (5)

4200 tonnes of ballast needed per 1 km track during its life (5)

In-situ ballast biosurfactants and bioremediation: theoretical performance

Bioremediation

Bioremediation is a natural and relatively low cost method of cleaning substrates fouled by hydrocarbons (2). In this study, the inclusion of bacteria pseudomonas putida was theorised and a successful process emitting water and carbon dioxide was the result. There was a sufficiently high bacteria survivability over the ballast life. It is probable that the carbon dioxide emitted is significantly less than the whole life carbon of new ballast. To support the theory, physical trials would now be proposed.

Biosurfactants

Biosurfactants are an effective way of preparing a substance for further bioremediation. They would form a film on the ballast and would help with the attachment of bioremediation causing bacteria. Theoretical approaches to bioremediation both with and without use of biosurfactants were considered, with its inclusion presenting marginally improved results in initial assessments.

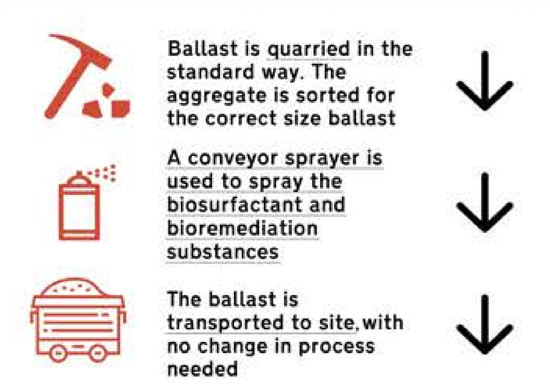

Fig 3: proposed manufacturing process of in-situ bioremediation ballast

Fig 4: proposed microbial electrochemistry of pseudomonas putida bioremediation of diesel in railway ballast

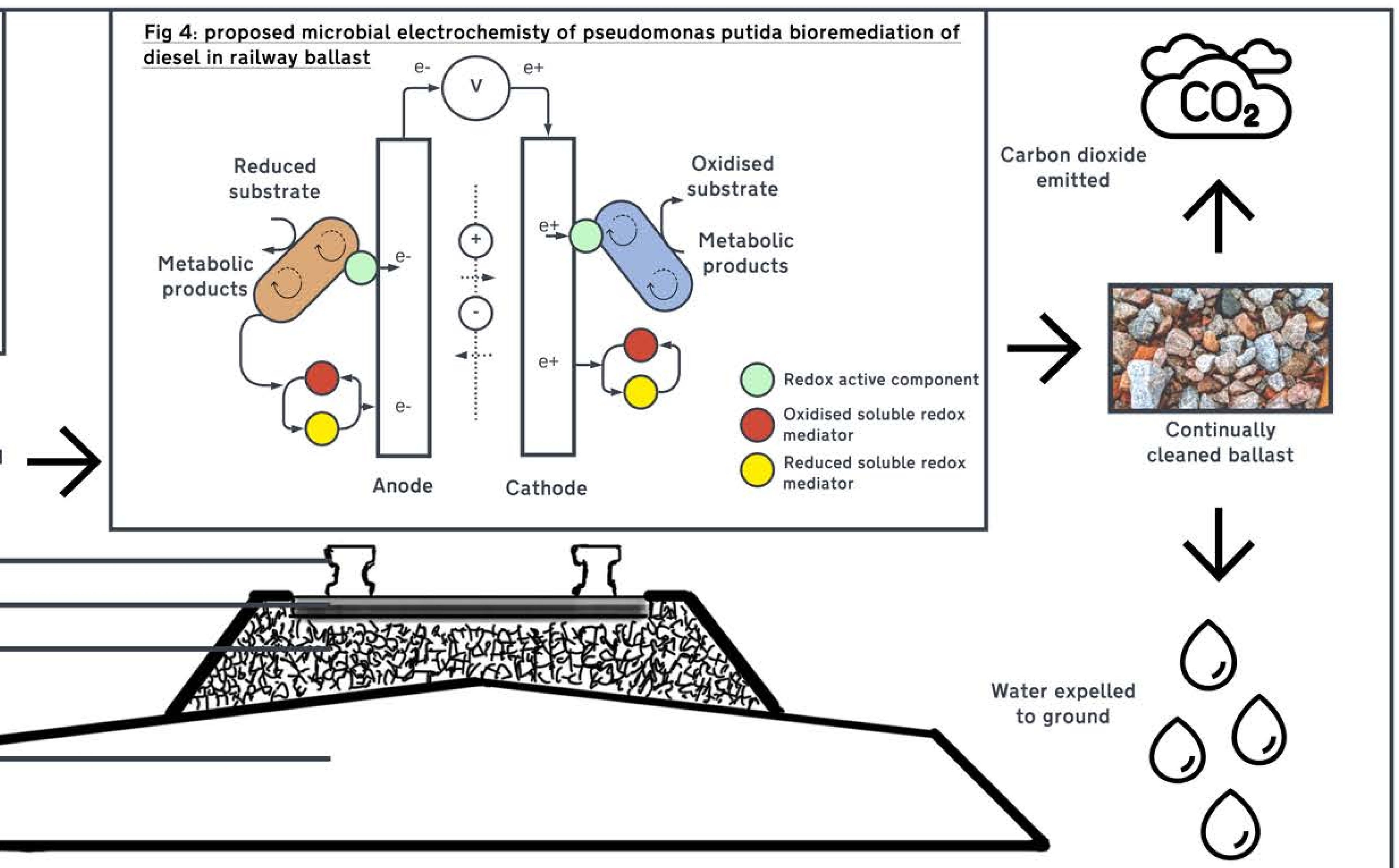

Fig 5: cross section of permanent way, showing a representation of the cleaning process

Sustainability

8.5 m less UK rail journeys cancelled per year (9)

£38m saving of UK public finances per year (8)

Carbon emissions from maintenance reduced by 2 %

It was found that, based on the lifecycle of ballast renewal and typical maintenance cycles (5), maintenance costs and time would be reduced up to 2%. Examples of ex-situ bioremediation on railway alreadyexist (1), however an in-situ approach would present vast cost and carbon savings through reduced movement of ballast.

Health and wellbeing

Maintenance of ballast is typically labour intensive. The railway industry is characterised by long hours and fatigue (3), and a reduction of shift workload intensity may present wellbeing benefits.

Silica dust is produced by ballast movement. The HSE estimates silica dust exposure was responsible for the death of over 500 construction workers in 2005 (6). Reduced maintenance would lead to reduced exposure and therefore safer work.

Fig. 6: dust production from ballast transport. Credit: Network Rail

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