Engineering Deinococcus Radiodurans for Remediation of Radioactive Mixed Waste Environments

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Immense volumes of radioactive waste, generated from nuclear weapons production during the Cold War, were disposed directly to the ground. The current expense of remediating these polluted sites is driving the development of alternative remediation strategies using microorganisms. Deinococcus radiodurans is the most radiation resistant organism known and can grow in highly irradiating environments. D. radiodurans strains expressing cloned mercury(II) resistance functions were constructed and shown to be effective at reducing toxic ionic mercury, a frequent constituent of radioactive wastes, to volatile elemental mercury. The mer operon was chosen as a model-system to guide future engineering efforts, particularly in the area of metal remediation.

To demonstrate how future engineering efforts of mixed radioactive wastes could be achieved, mercury-reducing and toluene-metabolizing functions were combined into the same host, yielding a strain expressing both functions. We have analyzed D. radiodurans growth on a chemically defined minimal medium in the presence and absence of continuous radiation. Whereas cell growth was unaffected in the absence of radiation, cells did not grow, and were killed, under continuous radiation. In nutrient-limiting conditions, DNA repair was found to be limited by this organism's metabolic capabilities and not by any nutritionally induced defect in genetic repair. Our growth studies and analysis of the complete D. radiodurans genomic sequence support the existence of several defects in D. radiodurans' global metabolic regulation that limit carbon, nitrogen and DNA metabolism. We have identified key nutritional constituents that restore growth of D. radiodurans in nutritionally limiting radioactive environments.