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INTEGRATED SYSTEM FOR TREATING SOIL CONTAMINATED WITH WOOD TREATING WASTES

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INTRODUCTION

Approximately 20% of the hazardous waste sites undergoing bioremediation are contaminated with wood treating wastes, primarily compounds such as pentachlorophenol (PCP), creosote, polycyclic aromatic hydrocarbons (PAHs), and other hydrocarbons (1). A process that combines soil washing with sequential anaerobic and aerobic biotreatment is being integrated to remediate soil contaminated with these wood treating wastes. By extracting the target compound from the soil, soil washing facilitates degradation by mobilizing the target compound and expanding the range of feasible remediation technologies. Additional flexibility is possible since soil washing can be conducted in an *in-situ* or *ex-situ* format. In this process, the wash solution is initially bioremediated in an anaerobic environment. Mineralization of the target compound is completed aerobically. Based on preliminary results, the integrated process could meet the target cleanup level for PCP in approximately 45% of the bioremediation sites (1).

Process development began by independently evaluating soil washing and target compound degradation. PCP contaminated soils were the initial focus, but this work is currently being extended to include soils contaminated with both PCP and PAHs. In addition, based on promising results from the soil washing and degradation evaluations, these individual unit operations are being integrated to form a complete process to remediate soils contaminated with wood treating wastes. This complete process incorporates soil washing, soil wash solution recycling, and biodegradation of the target compounds and is outlined in Figure 1.

RESULTS

Soil Washing

An ethanol and water mixture (mass fractions with soil: 0.02 soil, 0.49 ethanol, 0.49 water) has been selected as the soil washing solution. Compared to other ethanol-water mixtures, this mixture achieves the highest removal efficiency, 65% to 100% depending on soil size, contaminated age, and soil washing format. Comparing ethanol-water soil washing to the analytical procedures of soil sonication and soxhlet extraction, soil washing removes between 93% and 114% of the PCP removed by these analytical methods (2). With the equimass mixture of ethanol and water, essentially complete extraction is achieved in a 30 minute contact time. The ability of the ethanol-water mixture to remove PAHs from soil is being evaluated using naphthalene, acenaphthalene, pyrene, and benzo(b)fluoranthene as model compounds.

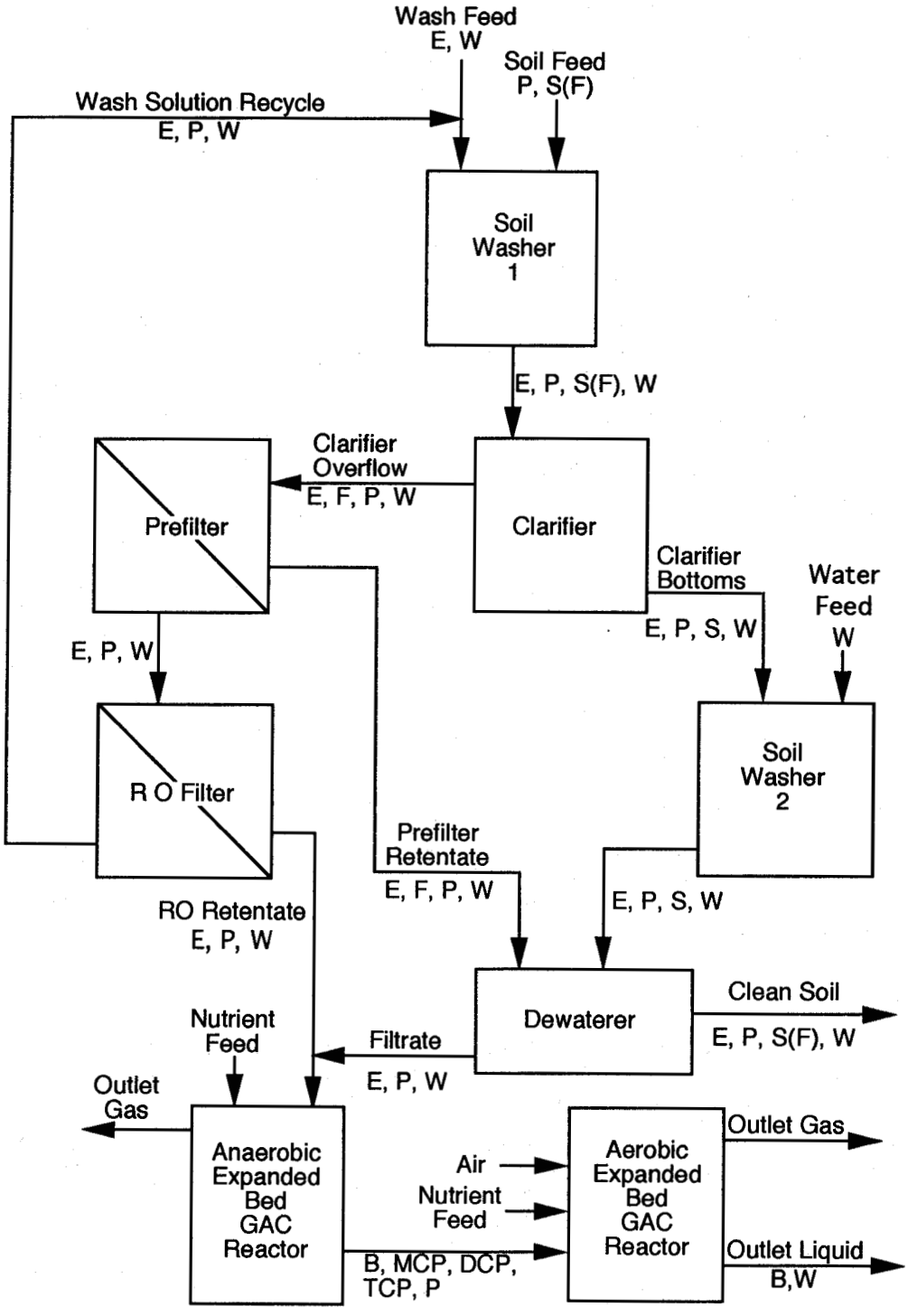

Figure 1. Integrated Process for Remediating Soil Contaminated with Wood Treating Wastes. The diagram details the flow of the following components: Biomass (B), Ethanol (E), Soil Fines (F), PCP (P), Soil (S), and Water (W).

Recycling Wash Solution

To reduce costs and the volume of PCP bearing liquid, the soil wash liquid will be concentrated and the removed ethanol and water will be recycled to the first soil washing unit. Reverse osmosis (RO) has been selected as the wash solution recycle operation to avoid the high energy costs of distillation. The feasibility of reverse osmosis will be determined in large part by the amount of wash solution which can be recycled and the economics of this process step.

Biodegradation

The retentate from the wash solution recycle process, the more concentrated wash solution, will be fed to an anaerobic expanded-bed granular activated carbon (GAC) reactor. The expanded-bed GAC reactor consists of a 96.5 cm Plexiglas tube with an internal diameter of 10.2 cm and an influent and effluent header. The reactor volume is 10 L including the recycle loop. Two of these reactors have been operated for over 40 months to evaluate variables such as PCP loading and retention time. When operated at retention times of 1.2 and 2.3 hours, greater than 99.97% of the influent PCP (0.6 g/day) is dechlorinated to monochlorophenol (MCP). The outlet stream from the reactor operating with the 2.3 hour retention time contains: 0.55 mmol MCP/L, 0.02 mmol dichlorophenol (DCP)/L, 0.005 mmol phenol/L, 0.0008 mmol PCP/L, and 0.00035 mmol trichlorophenol (TCP)/L. Inhibition of the microbial cultures in these reactors, presumably by elevated levels of MCP, was alleviated by decreasing the PCP feed rate to the current level of 0.6 g/day. Ethanol is also included in the reactor feed stream at a level of 33.3 g/day; however, the ethanol feed in the integrated process will be determined by the wash solution recycle process unit.

The outlet stream from the anaerobic expanded-bed GAC reactor will be fed to an aerobic expanded-bed GAC reactor. Under aerobic conditions, the remaining chlorinated compounds should be mineralized (3). Since analysis of the anaerobic reactor is nearly complete, characterization and optimization of the aerobic reactor will begin shortly.

In addition, experiments to characterize an anaerobic expanded-bed GAC reactor fed PCP and the four model PAHs have begun. An 11 L slurry-type reactor is also being evaluated. These reactors are also feed ethanol as a primary substrate.

CONCLUSIONS

A process integrating soil washing and sequential anaerobic-aerobic biodegradation may be an effective method of remediating wood treating wastes. The process meets the target cleanup level in 45% of the PCP bioremediation sites, or less than 35 mg PCP/kg soil. Soil washing with a mixture of ethanol and water removes PCP at levels comparable to those achieved through the analytical techniques of soil sonication and soxhlet extraction. Following soil washing, some of the soil washing solution will be recycled. The concentrated PCP bearing liquid is fed to an anaerobic expanded-bed GAC reactor where 99.97% of the PCP is reduced to MCP. The outlet from the anaerobic reactor feeds an aerobic expanded-bed reactor that should mineralize the remaining chlorinated phenols.

Current efforts are directed towards adapting the process to soils contaminated with both PCP and PAHs, evaluating reverse osmosis as a means of recycling the soil washing solution, and integrating the process.

REFERENCES

1. Bioremediation in the Field No. 11. EPA/540/N-94/501, U. S. Environmental Protection Agency, 1994. 63 pp.

2. Khodadoust, A. P.; Wagner, J. A.; Suidan, M. T.; Safferman, S. I. Solvent Washing of Aged PCP-Contaminated Soils. Paper presented in 1993 at the Water Environment Federation, Anaheim, California. October, 1993.

3. Rochkind, M. L. and Blackburn, J. W. Microbial Decomposition of Chlorinated Aromatic Compounds. EPA/600/2-86/090, U. S. Environmental Protection Agency, Cincinnati, Ohio, 1986. 269 pp.

FOR MORE INFORMATION

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