Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for review maintaining the data needed, and completing and evelocitie of information paradiants to two data needed, and completing and evelocitie of order office and completing and evelocitie of information of paradiants to two data needed, and control information of the order order of the order of the order of the order of the or	Ing instructions, searchill estimate or any other as 215 Jefferson Davis Hig ND DATES COVE 994 5. FUNDING N/A 8. PERFORM REPORT M EPA/600/R 10. SPONSO AGENCY N/A April 1995. No nse to exercise a	AING ORGANIZATION NUMBERS AING ORGANIZATION NUMBER 2-95/058 PRING / MONITORING Y REPORT NUMBER
suggestions for reducing this burden to Washington Headquarters Services, Directorize for Information Operations and Reports, 1. AGENCY USE ONLY (Leave blank) 2. REPORT DATE April 1995 4. TITLE AND SUBTITLE Remediation Using Plants and Plant Enzymes: A Progress Report 6. AUTHOR(S) Environmental Research Laboartory Office of Research and Development 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Environmental Research Laboartory Office of Research and Development 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Environmental Research Laboartory Office of Research and Development 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) SERDP 901 North Stuart St. Suite 303 Arlington, VA 22203 11. SUPPLEMENTARY NOTES Published in Environmental Research Laboratory-Athens, GA 1994 Highlights, p. 2 United States under Title 17, U.S. code. The U.S. Government has a royalty-free lice claimed herein for Government purposes. All other rights are reserved by the copyri 12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release: distribution is unlimited 13. ABSTRACT (Maximum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antiDodeis to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardoo RDX and HMX has led to a new approach to remediationphytoremediation. Invest	215 Jefferson Davis Hig ND DATES COVE 994 5. FUNDING N/A 8. PERFORM REPORT N EPA/600/R 10. SPONSO Agency N/A	ANNAY, Suite 1204, Arlington, VA 22202-4302. RED NUMBERS ANNA ORGANIZATION NUMBER 3-95/058 PRING / MONITORING Y REPORT NUMBER D Copyright is asserted in the
April 1995 Progress report, A. TITLE AND SUBTITLE Remediation Using Plants and Plant Enzymes: A Progress Report S. AUTHOR(S) Environmental Research Laboartory Office of Research and Development Progress (ES) PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Environmental Research Laboartory Office of Research and Development US EPA 260 Coolege Station Road Athens, GA 30605-2700 28. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) SERDP 2001 North Stuart St. Suite 303 Adrington, VA 22203 11. SUPPLEMENTARY NOTES Published in Environmental Research Laboratory-Athens, GA 1994 Highlights, p. 2 United States under Title 17, U.S. code. The U.S. Government has a royalty-free lice Icaimed herein for Government purposes. All other rights are reserved by the copyri 12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release: distribution is unlimited 13. ABSTRACT (Maximum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDA ADDRESS (S) Sediments have been and partially chara been used for the production of monoclonal antibodies to determine the po	994 5. FUNDING N/A 8. PERFORM REPORT 1 EPA/600/R 10. SPONSO AGENCY N/A April 1995. No nse to exercise a	NUMBERS MING ORGANIZATION NUMBER 3-95/058 PRING / MONITORING Y REPORT NUMBER
Remediation Using Plants and Plant Enzymes: A Progress Report	N/A 8. PERFORM REPORT f EPA/600/R 10. SPONSO AGENCY N/A April 1995. No nse to exercise a	AING ORGANIZATION NUMBER 2-95/058 PRING / MONITORING Y REPORT NUMBER
Environmental Research Laboartory Office of Research and Development 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Environmental Research Laboartory Office of Research and Development US EPA 960 Coolege Station Road Athens, GA 30605-2700 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) SERDP 901 North Stuart St. Suite 303 Arlington, VA 22203 11. SUPPLEMENTARY NOTES Published in <u>Environmental Research Laboratory-Athens, GA 1994 Highlights</u> , p. 2 United States under Title 17, U.S. code. The U.S. Government has a royalty-free lice claimed herein for Government purposes. All other rights are reserved by the copyri 12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release: distribution is unlimited 13. ABSTRACT (MaxImum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest	REPORT N EPA/600/R 10. SPONSO Agency N/A	NUMBER -95/058 PRING / MONITORING / REPORT NUMBER 0 copyright is asserted in the
Environmental Research Laboartory Office of Research and Development US EPA 960 Coolege Station Road Athens, GA 30605-2700 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) SERDP 901 North Stuart St. Suite 303 Arlington, VA 22203 11. SUPPLEMENTARY NOTES Published in Environmental Research Laboratory-Athens, GA 1994 Highlights, p. 2 United States under Title 17, U.S. code. The U.S. Government has a royalty-free lica claimed herein for Government purposes. All other rights are reserved by the copyri 12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release: distribution is unlimited 13. ABSTRACT (Maximum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroarom solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest	REPORT N EPA/600/R 10. SPONSO Agency N/A	NUMBER -95/058 PRING / MONITORING / REPORT NUMBER 0 copyright is asserted in the
Office of Research and Development US EPA 960 Coolege Station Road Athens, GA 30605-2700 a. sponsoring / MONITORING AGENCY NAME(S) AND ADDRESS(ES) SERDP 901 North Stuart St. Suite 303 Arlington, VA 22203 11. SUPPLEMENTARY NOTES Published in Environmental Research Laboratory-Athens, GA 1994 Highlights, p. 2 United States under Title 17, U.S. code. The U.S. Government has a royalty-free licc claimed herein for Government purposes. All other rights are reserved by the copyri 12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release: distribution is unlimited 13. ABSTRACT (MaxImum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest	10. SPONSO AGENCY N/A April 1995. No nse to exercise a	PRING / MONITORING REPORT NUMBER
 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) SERDP 901 North Stuart St. Suite 303 Arlington, VA 22203 11. SUPPLEMENTARY NOTES Published in Environmental Research Laboratory-Athens, GA 1994 Highlights, p. 2 United States under Title 17, U.S. code. The U.S. Government has a royalty-free lica claimed herein for Government purposes. All other rights are reserved by the copyri, 12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release: distribution is unlimited 13. ABSTRACT (MaxImum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest 	AGENCY N/A April 1995. No nse to exercise a	Copyright is asserted in the
 Arlington, VA 22203 11. SUPPLEMENTARY NOTES Published in Environmental Research Laboratory-Athens, GA 1994 Highlights, p. 2 United States under Title 17, U.S. code. The U.S. Government has a royalty-free lice claimed herein for Government purposes. All other rights are reserved by the copyri 12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release: distribution is unlimited 13. ABSTRACT (MaxImum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest 	nse to exercise a	o copyright is asserted in the all rights under the copyright
 Published in Environmental Research Laboratory-Athens, GA 1994 Highlights, p. 2 United States under Title 17, U.S. code. The U.S. Government has a royalty-free lice claimed herein for Government purposes. All other rights are reserved by the copyrine transmission of the public release: All other rights are reserved by the copyrine transmission of the public release: distribution is unlimited 13. ABSTRACT (MaxImum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially charabeen used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest 	nse to exercise a	o copyright is asserted in the all rights under the copyright
Approved for public release: distribution is unlimited 13. ABSTRACT (MaxImum 200 Words) Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest		
Sediments have been shown to contain active enzymes that can degrade nitroaron solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest		12b. DISTRIBUTION CODE A
solvents such as TCE. Five classes of proteins have been isolated and partially chara been used for the production of monoclonal antibodies to determine the possible sour are plants growing near the sediment. The use of plants for remediation of hazardou RDX and HMX has led to a new approach to remediationphytoremediation. Invest		
	cterized. Three of these protest materials such	of the classes of proteins have eins. In every case, the sources as TNT or other munitions like
14. SUBJECT TERMS sediments, TNT, TCE, monoclonal antibodies, RDX, HMX, phytoremediation, SERI	 PP	15. NUMBER OF PAGES
		16. PRICE CODE N/A
17. SECURITY CLASSIFICATION OF REPORT 18. SECURITY CLASSIFICATION OF THIS PAGE 19. SECURITY CLA 0F REPORT 0F ABSTRACT 0F ABSTRACT		
unclass unclass unclass unclass	SIFICATION	20. LIMITATION OF ABSTRAC





50 100 150







Remediation Using Plants and Plant Enzymes: A Progress Report

Sediments have been shown to contain active enzymes that can degrade nitroaromatic compounds such as TNT or chlorinated solvents such as TCE. Five classes of proteins have been isolated and partially characterized. Three of the enzymes have been used for the production of monoclonal antibodies to determine the possible sources of these proteins. In every case, the sources are plants growing near the sediment. The use of plants for remediation of hazardous materials such as TNT or other munitions like RDX and HMX has led to a new approach to remediation--phytoremediation. Investigators have developed a field test to indicate which locally grown plants can be used at each contaminated site.

Pilot scale testing of the concept of phytoremediation is being funded by the Strategic Environmental Research and Development Program. Created wetlands containing appropriate plants will be used to remove TNT from ground water.

TNT half life of minutes

Halflives of TNT with the appropriate plants are on the order of minutes in the laboratory compared with 15 to 20 days for composting and 80 days for bacterial breakdown. Investigations have shown that the TNT is reduced one nitro group at a time to triaminotolune (TAT) by one enzyme, a nitroreductase. A second enzyme present in some plants, a lactase, adds oxygen across the ring structure and opens it up. The reaction after ring opening is very rapid, and no TNT remains, and the components of the TNT molecule may be incorporated into the plant, perhaps as lignin.

Phytoremediation is also applicable to the cleanup of TNT-contaminated soil. Auburn University, in cooperation with EPA, has conducted a series of batch pilot studies at an abandoned ammunition plant in Alabama. The Georgia Institute of Technology, Rice University, and Louisiana State University will conduct soil cleanup pilot studies in 1995 using soils contaminated up to 5000 ppm, under an EPA grant to the Hazardous Substance Research Center/South and Southwest. (*N.L. Wolfe and S.C. McCutcheon; 706-546-3429*)