

Phosphatic Clay for Agricultural Uses: Bibliography¹

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Introduction

Phosphatic clays are by-products of the phosphate mining industry in central Florida. These clays have unique properties, including approximately 2% phosphorus, which remains after the mining and beneficiation processes. Compared to the sandy soils of Florida, phosphatic clays are highly fertile with high water holding capacity. As of this writing, there are more than 100,000 acres of phosphatic clays within Florida. Research and extension efforts have focused on identifying the benefits, risks, and challenges of using phosphatic clays in agricultural production while protecting Floridas natural environment.

The following is a structured bibliography of information that was generated in large part by the Polk County Mined Lands Agricultural Research and Demonstration Project with related research programs and documents. This joint project between the University of Florida, Institute of Food and Agricultural Sciences (IFAS); the Florida Institute of Phosphate Research (FIPR); Natural Resource and Conservation Service (NRCS); and the Polk County Board of County Commissioners addressed the

problems and opportunities presented by phosphatic clays.

This document can be used by growers, land owners, government agency staff members, and elected officials who wish to know more about phosphatic clay as a valuable resource of Florida. This bibliography is divided into sections based upon subject area. The contents of this EDIS document shall be updated in 2008 following the normal UF/IFAS three-year revision policy.

General overview of phosphatic clays

Documents in this section describe the creation of phosphatic clays during the mining operations, transport, deposition, reclamation including dewatering, and findings at selected states of completion.

Journal Articles

Hochmuth, G.J., E.A. Hanlon, and J.A. Stricker. 1986. Production of high-value crops on reclaimed phosphate mined lands. *Am. Soc. Hort. Sci.* 4-16 Aug. *HortScience* 21:738.

1. This document is SL224, one of a series of the Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date April 2005. Reviewed April 2008 and February 2011. Visit the EDIS website at <http://edis.ifas.ufl.edu>.

2. Edward A. Hanlon, professor, Soil and Water Science Department, Southwest Florida Research and Education Center, Immokalee, FL; James A. Stricker, Polk County Extension Director and Extension Agent IV (retired), Bartow, FL; and J Carson, Media Coordinator, Southwest Florida Research and Education Center, Immokalee, FL, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

Hochmuth, G.J., E.A. Hanlon, and J.A. Stricker. 1987. Crop production on reclaimed phosphate-mined soils in Florida. *HortScience* 22:189-191.

Proceedings and Florida Journals

Stricker, J.A. 1991. Agricultural use of reclaimed phosphate waste clays, *In Proc. 41st Annual Meeting of the Fertilizer Industry Round Table*, Tampa, FL. Oct. 21-23. The Fertilizer Industry Round Table, Washington, DC. p. 98-104.

Stricker, J.A. 2000. High value crop potential of reclaimed phosphatic clay soil. *In Proc. Amer. Soc. Surface Mining and Reclamation. Annual Meeting of the Amer. Soc. Surface Mining and Reclamation*. Tampa, FL. 11-15 June. 11 pp.

Reports and Dissertations

Zang, P. and G.R. Albarelli. 1995. Phosphatic clay bibliography. Florida Institute of Phosphate Research, Bartow, FL. Publication No. 02-097-114. 322 pp.

Abstracts

Bondurant, M., and E.A. Hanlon. 1991. Agricultural alternatives for the clay wastes of phosphate mining. Mined Lands Agricultural Research/Demonstration Project. Fla. Coop. Extn. Serv., IFAS, Univ. of Fla., Gainesville, FL. 2 pp.

Hanlon, E.A. 1988. Mined lands agricultural research/demonstration project research plan. Fla. Coop. Extn. Serv., IFAS, Univ. of Fla., Gainesville, FL. 5 pp.

Stricker, J.A., E. Caldwell, M.F. Cole, E.A. Hanlon, G.J. Hochmuth, W.D. Mulkey, G.M. Price, L.N. Shaw, J. Tallent, and F. Wilson. 1987. Mined lands program launched by cooperative effort. Fla. Assoc. of County Agric. Agents. Abst. 1 p.

Extension Publications

Stricker, J.A. 1993. A brief overview of the Polk County mined lands agricultural research/demonstration project, Oct. 1985 to Feb. 1993. Univ. of Fla./Polk County Coop. Extn. Serv. Bartow, FL. Xerox, 6 pp.

Presentations, Videos, and Training Sessions

English Language Institute Seminar. 1989. Reclamation of phosphatic clays in central Florida. Gainesville, FL. Attendance: 15.

Field Day. 1987. Polk County agricultural research/demonstration project: Soils management. Attendance: 64 including the Lt. Governor and other state political figures.

Field Day. 1989. Tillage and soil management of phosphatic clays. (four 15-minute presentations). Bartow, FL. Attendance: 150.

Grower meeting. 1990. Use of phosphatic clays. (one-day workshop, chair: Hanlon, E.A.). Bartow, FL. Attendance: 50.

Soils

Because phosphatic clay is much different than the traditional sandy soils of Florida, many management aspects of phosphatic clay in an agricultural setting are addressed. Steps in reclamation, surface drainage (macrobeds), erosion prevention, tillage and surface roughness, water-table management, bed-mellowing (clod reduction), trafficability, and selection of tillage equipment for selected operations are explained. (*See Radionuclide section below*).

Proceedings and Florida Journals

Stricker, J.A. 2004. Stormwater Runoff from Phosphatic Clay Soiland Estimated Cost. *Soil Crop Sci. Soc. Florida Proc.* 63:84.

Reports and Dissertations

Haman, D.Z., E.A. Hanlon, J.A. Stricker, D.L. Anderson, G. Gao, and W.R. Reck. 2001. Managing runoff water quality from clay settling areas used for intensive agricultural production.

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Bartow, FL. Pub. No. 03-114-146. 57 pp.

Hanlon, E.A., R.A. Jerez, and J.A. Stricker (eds.) 1996. The mined lands agricultural research and demonstration project: Summary of experiments and extension recommendations. Florida Institute of Phosphate Research. Bartow, FL. Pub. No. 03-093-128. 115 pp.

The following articles are found in the reference cited above in bold font.

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Hanlon, E.A., R.A. Jerez, D.B. Shibles, and T.C. Riddle. 1996. Drainage control. p. 33-35.

Hanlon, E.A., R.A. Jerez, E.C. French, and T.C. Riddle. 1996. Perennial peanut for trafficability. p. 36-39.

Jerez, R.A., E.A. Hanlon, and G.J. Hochmuth. 1996. Seedbed preparation. p. 31-32.

Schwandes, L., R.A. Jerez, E.A. Hanlon, and G.J. Hochmuth. 1996. Comparison of soil extractants. p. 27-30.

Shibles, D.B. (ed.) 1994. Polk County mined lands agricultural research/demonstration project report: Three-year summary. Florida Institute of Phosphate Research. Bartow, FL. FIPR Publ. No. 03-088-107.

The following articles are found in the reference cited above in bold font.

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Hanlon, E.A., G.J. Hochmuth, and T.C. Riddle. 1994. Tillage equipment selection for vegetable bed preparation. p. 89-90.

Shibles, D.B., T.C. Riddle, and E.A. Hanlon. 1994. Dewatering studies. p. 112-116.

Abstracts

French, E.C., and E.A. Hanlon. 1990. Perennial peanut sod: a stabilizing rhizome matrix for moist phosphatic clay soil. Soil Sci. Soc. Am. San Antonio, TX, 21-26 Oct. Agron. Abst. p. 142.

Gao, D., and E.A. Hanlon. 1997. Sediments and associated P in runoff from reclaimed phosphatic clay. Environ. Chem. Workshop, Indiana Univ. Bloomington, IN, 8-9 Nov. (Abstract).

Hanlon, E.A. 1991. Symposium synopsis addressing naturally occurring radionuclides in agriculture products. Soil Sci. Soc. Am. Denver, CO, 27 Oct.-1 Nov. Agron. Abst. p. 289.

Hanlon, E.A., J.C. Graddy, and J.A. Valenti. 1992. Naturally occurring radionuclides in agricultural products: Extension efforts. Am. Soc. Agron. Minneapolis, MN, 1-6 Nov. Agron. Abst. p. 27.

Jerez, R.A., E.A. Hanlon, and G.J. Hochmuth. 1988. Use of a relief meter in the reclamation process of phosphatic clays in Florida. Soil Sci. Soc. Am. Anaheim, CA, 27 Nov.-2 Dec. Agron. Abst. p. 277.

Patel, S.K., J.B. Sartain, S.G. Richardson, and E.A. Hanlon. 1991. Effects of dolomite, phosphatic clay, and sewage sludge on the pH and electrical conductivity of phosphogypsum. Soil Sci. Soc. Am. Denver, CO, 27 Oct.-1 Nov. Agron. Abst. p. 250.

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Hanlon, E.A., and R.D. Ford. 1994. Reclaimed phosphatic clays: surface drainage and water table measurements. Univ. of Fla. Coop. Extn. Serv., Gainesville, FL. SS-MLR-6. 4 pp.

Hanlon, E.A., G.J. Hochmuth, L. Shaw, and C. Riddle. 1993. Tillage for vegetable-crop production on phosphatic clays. Mined Lands Agricultural Research/Demonstration Project. Production Guide SS-MLR-4. 6 pp.

Hanlon, E.A., H.W. Kananen, and E.C. French. 1994. Guidelines for reclaiming clay settling areas for intensive agricultural uses. Univ. of Fla. Coop. Extn. Serv., Gainesville, FL. SS-MLR-1. 7 pp.

Presentations, Videos, and Training Sessions

Gao, D., and E.A. Hanlon. 1995. Application of GLEAMS to estimate runoff, erosion, and nutrient losses from phosphatic clay. Presentation: Soil Crop Sci. Soc. Fla., Daytona Beach, FL.

Hanlon, E.A. 1990. Soil management of phosphatic clays. (eight minutes of 22-minute video). Bartow, FL.

Hanlon, E.A., J.A. Stricker, D.Z. Haman, D.L. Anderson. 1996. Runoff water quality from clay settling areas used for intensive agricultural production. Invited. 11th Annual Regional Phosphate Conference, Am. Inst. Mining Eng., 18 Oct. Lakeland, FL.

Agronomic crops

Articles address rice, perennial peanut, bio-mass crops, and selected row crop production practices on phosphatic clay.

Journal Articles

French, E.C., E.A. Hanlon, and G.J. Hochmuth. 1989. Perennial peanut-corn association on phosphatic clay settling pond soil. Fla. Acad. Sci. Orlando, FL. 12 Apr. Vol. 52:4.

Mislevy, P., W.G. Blue, and C.E. Roessler. 1989. Productivity of clay tailings from phosphate mining. I. Biomass crops. J. Environ. Qual. 18:95-100.

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Baltensperger, D.D., G.M. Prine, and D.S. Wofford. 1989. Phosphatic settling pond clays as potential forage legume seed production site. p. 1627-1628. *In Proceedings XVI International Grassland Congress at Nice, France.*

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Prine, G.M., D.L. Rockwood, and J.A. Stricker. 2000. Many short rotation trees and herbaceous plants available as energy crops in humid lower south. *In Proc. Of Bioenergy 2000, Northeast Regional Biomass Program, 400 N. Capital St., NW, Suite 382, Washington, DC, Oct. 15-19.*

Prine, G.M., and K.R. Woodard. 1994. Leucaena and tall grasses as energy crops in humid Lower South USA. p. 681-688. *In Proc. Sixth National Bioenergy Conf.: Bioenergy 94, Using Biofuels for a Better Environment. Reno/Sparks, NV. 2-6 Oct. Vol. 2.*

Segrest, S.A., D.L. Rockwood, J.A. Stricker, A.E.S. Green, W.H. Smith, and D.R. Carter. 1998. Biomass co - Firing with coal at Lakeland, Florida, utilities. *In Proc. BioEnergy 98, Expanding BioEnergy Partnerships. Madison, WI. Oct. 4-8. p. 315-325.*

Stricker, J.A., G.M. Prine, D.L. Anderson, D.B. Shibles, and T.C. Riddle. 1996. p. 822-829. Biomass/energy crops grown on phosphatic clay in central Florida. *In Proc. BioEnergy 96, Seventh National Bioenergy Conference. Nashville, TN. 15-19 Sept. Vol. 2.*

Stricker, J.A., G.M. Prine, and T.C. Riddle. 1997. Yield of kenaf grown on two locations in Florida. *Proc. Soil and Crop Sci. Fla. 56:35-37.*

Stricker, J.A., G.M. Prine, K.R. Woodard, and D.B. Shibles. 1993. Biomass yield of tall grass energy crops on phosphatic clay in central Florida. *Proc. Soil Crop Sci. Soc. Fla. 52:4-6.*

Stricker, J.A., P.G. Tuohy, M. Rahmani, and A.W. Hodges. 1997. Scale-up of a dedicated biomass feedstock system for production of ethanol and electricity. *In Proc. Third Biomass Conference of the Americas. Montreal, Quebec, Canada. Aug 24-29. p 1093-1101.*

Reports and Dissertations

Eitzen, J.B. 1990. Ratoon rice analysis on phosphatic clay soil. Univ. of Fla. Dissertation. 144 pp.

Proc. first biomass conf. of the Americas: Energy, environment, agriculture, and industry. 1993. Burlington, VT. 30 Aug.-2 Sept. Vol. 1.

The following articles are found in the reference cited above in bold font.

Prine, G.M., and K.R. Woodard. 1993. Herbaceous energy crops in humid Lower South USA. p. 278-279.

Stricker, J.A., G.M. Prine, K.R. Woodard, D.L. Anderson, D.B. Shibles, and T.C. Riddle. 1993. Production of biomass/energy crops on phosphatic clay soils in central Florida. p. 254-259.

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Stricker, J.A., A.W. Hodges, M. Rahmani, J.W. Mishoe, G.M. Prine, D.L. Rockwood, and A. Vincent. 1995. Economic development through biomass systems integration in central Florida. p. 1608-1617.

Hanlon, E.A., R.A. Jerez, and J.A. Stricker (eds.) 1996. The mined lands agricultural research and demonstration project: Summary of experiments and extension recommendations. Florida Institute of Phosphate Research. Bartow, FL. Pub. No. 03-093-128. 115 pp.

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French, E.C., G.M. Prine, J.A. Stricker, T.C. Riddle, and D.B. Shibles. 1996. Multiple cropping on phosphatic clay soil. p. 93-96. Text adapted by R.A. Jerez and E.A. Hanlon.

French, E.C., G.M. Prine, J.A. Stricker, D.B. Shibles, and T.C. Riddle. 1996. Alfalfa and perennial peanut cutting frequency study. p. 73-74.

French, E.C., T.C. Riddle, J.E. Hollister, and G.M. Prine. 1996. Overseeding of Florigraze perennial peanut with cool season crops. p. 97-98. Text adapted by R.A. Jerez and E.A. Hanlon.

Hanlon, E.A., R.A. Jerez, D.B. Shibles, and T.C. Riddle. 1996. Temperate field corn production. p. 110-111.

Pitman, W.D., E.C. French, and G.M. Prine. 1996. Perennial tropical legume screening on phosphatic clay. p. 103-105. Text adapted by R.A. Jerez and E.A. Hanlon.

Prine, G.M., E.C. French, T.C. Riddle, and J.A. Stricker. 1996. Rice production. p. 106-107. Text adapted by R.A. Jerez and E.A. Hanlon.

Prine, G.M., E.C. French, D.B. Shibles, and J.A. Stricker. 1996. Early grain sorghum trials on phosphatic clay soil. p. 79-83. Text adapted by R.A. Jerez and E.A. Hanlon.

Prine, G.M., E.C. French, and J.A. Stricker. 1996. Forage legume seed production. p. 84-85. Text adapted by R.A. Jerez and E.A. Hanlon.

Prine, G.M., C.K. Hiebsch, E.C. French, and J.A. Stricker. 1996. Soybean cultivar performance. p. 108-109. Text adapted by R.A. Jerez and E.A. Hanlon.

Prine, G.M., R.C. Stephenson, E.C. French, and J.A. Stricker. 1996. Corn for grain and/or silage on phosphatic clays. p. 112-115. Text adapted by R.A. Jerez and E.A. Hanlon.

Prine, G.M., J.A. Stricker, E.C. French, D.B. Shibles, and T.C. Riddle. 1996. Kenaf, pulp and fiber crop for phosphatic clays. p. 90-92. Text adapted by R.A. Jerez and E.A. Hanlon.

Stricker, J. A., G. M. Prine, D. L. Anderson, D. B. Shibles, and T. C. Riddle. 1996. Biomass/energy crops grown on phosphatic clay. p. 86-89. Text adapted by R.A. Jerez and E.A. Hanlon.

Shibles, D. (ed.) 1994. Polk County mined lands agricultural research/demonstration project report: Three-year summary. Florida Institute of Phosphate Research. Bartow, FL. FIPR Publ. No. 03-088-107.

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French, E.C., W.D. Pitman, G.M. Prine, J.A. Stricker, D.B. Shibles, T.C. Riddle, and J.E. Spofford. 1994. Yield and quality comparison of alfalfa, perennial peanut, and desmanthus for livestock feed. p. 154-156.

French, E. C., G. M. Prine, E. A. Hanlon, J. A. Stricker, D. B. Shibles, T. C. Riddle, K. R. Woodard. 1994. Establishment strategies for forage perennial peanut on phosphatic clay. p. 150-153.

French, E.C., G.M. Prine, C.K. Hiebsch, R.D. Barnett, J.A. Stricker, D.B. Shibles, T.C. Riddle, and K.R. Woodard. 1994. Multiple

cropping on phosphatic clay soils in Polk County, Florida. p. 137-149.

Jones, D., J. Eitzen, and T.C. Riddle. 1994. Effect of main crop nitrogen fertilizer on ratoon yield. p. 179-186.

Jones, D.B, C. Riddle, and J. Eitzen. 1994. Rice performance trial. p. 170-178.

Mulkey, W.D., R.L. Clouser, and T.G. Taylor. 1994. Estimated production costs for selected vegetables produced on reclaimed phosphatic clay soils. p. 4-24.

Pitman, W.D. 1994. Alfalfa reseeding. p. 163-165.

Pitman, W.D. 1994. Perennial tropical legume screening on mined phosphatic clay. p. 156-162.

Rahmani, M., and R. Degner. 1994. Market opportunities for feed grains and alfalfa hay produced on reclaimed phosphatic clay in Florida. p. 25-50.

Shibles, D.B., E.A. Hanlon, and T.C. Riddle. 1994. Temperate field corn study. p. 166-169.

Stricker, J.A., and P.G. Tuohy. 1998. Dedicated feedstock supply system for production of ethanol and electricity. Final report. Southeast Regional Biomass Energy Program, Muscle Shoals, AL. Sept. 18. 13 pp.

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Stricker, J.A. and G.M. Prine. 1998. Kenaf – a tree-free fiber crop for reclaimed phosphate land. Natural Resources Forum 98: Linkages in Ecosystem Science, Management and Restoration. June 9-10. Radisson Hotel, Gainesville, FL. p 162.

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Shibles, D B., J.A. Stricker, G.M. Prine, E.A. Hanlon, CR. Staples, E.C. French, and T.C. Riddle. 1994. Production and management of alfalfa on phosphatic clay in Florida. Univ. of Fla. Coop. Extn. Serv., Gainesville, FL. SS-MLR-2. 10 pp.

Stricker, J.A., G.M. Prine, D.L. Anderson, D.B. Shibles, and T.C. Riddle. 1993. Production and management of biomass/energy crops on phosphatic clay in central Florida. Univ. of Fla. Coop. Extn. Serv., Gainesville, FL. Cir. 1084. 8 pp.

Stricker, J.A., G.M. Prine, and T.C. Riddle. 1998. Kenaf—A possible new crop for central Florida. Univ. of Fla. Coop. Extn. Serv., Gainesville, FL. SS-AGR-68. 11 pp.

Talbot, M.T., S.A. Smith, R.L. Clouser, and T.G. Taylor. 1994. Economics of artificially drying alfalfa or perennial peanut for hay in central Florida. Univ. of Fla. Coop. Extn. Serv., Gainesville, FL. SS-MLR-9. 14 pp.

Vegetable crops

The fine-textured phosphatic clay required much less fertilization than vegetables produced on sandy soils. Irrigation was often needed to establish the crop, and transplanting was often superior to seeding. Crops included watermelon, tomato, bell pepper, squash, cabbage, and cauliflower.

Reports and Dissertations

Hanlon, E.A., R.A. Jerez, and J.A. Stricker (eds.) 1996. The mined lands agricultural research and demonstration project: Summary of experiments and extension recommendations. Florida Institute of Phosphate Research. Bartow, FL. Pub. No. 03-093-128. 115 pp.

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Jerez, R.A., E.A. Hanlon, and G.J. Hochmuth. 1996. Watermelon production. p. 63-65.

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Hochmuth, G.J. 1994. Stand establishment experiment Oct. 26, 1989. p. 197-199.

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Hochmuth, G.J., and E.A. Hanlon. 1989. Production of summer squash on phosphatic clays of Florida. Fla. Coop. Extn. Serv., IFAS, Univ. of Fla., Gainesville, FL. Production Guide SS-MLR-902. 6 pp.

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Hanlon, E.A., G.J. Hochmuth, and C. Riddle. 1992. Tillage for vegetable-crop production on phosphatic clays. Fla. Coop. Extn. Serv., IFAS, Univ. of Fla., Gainesville, FL. Production Guide SS-MLR-903. 6 pp.

Sod production on phosphatic clays

Proceedings and Florida Journals

Dudeck, A.E. 1990. Influence of planting method, fertility program, cultivar, and sod type on St. Augustinegrass. Proc. Fla. State Hort. Soc. 103:355

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Freeman, T.E. (ed.) 1989. Turfgrass research in Florida. IFAS Tech. Report. Mar.

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Dudeck, A.E. 1989. St. Augustinegrass establishment on reclaimed phosphate settling ponds. p. 21-26.

Dudeck, A.E. 1989. St. Augustinegrass fertilizer studies for sod production. p. 37-42.

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Tree production on phosphatic clays

Proceedings and Florida Journals

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College of Environ. Sci. and Forestry.
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Economics of agricultural activities on phosphatic clay

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Radionuclides in phosphatic clays

Small amounts of radioactive substances, called radionuclides, are found in phosphatic clay. These articles describe work with beef cattle, agronomic crops, and the findings of a national symposium addressing radionuclides in agricultural products. While phosphatic clay does contain more radionuclides than adjacent mineral soils, researchers and food safety experts found that dietary health risks to humans were extremely low and declared agricultural products produced on phosphatic clay safe for entry into the human food chain. Since crops accumulate radionuclides at different rates, handling and preparation issues were described to further reduce possible exposure. Risk analysis showed that riding in a car today carries with that action a 1-in-4,000 chance of dying in a car accident. This risk is considered acceptable by millions of drivers. The risk of dietary exposure to radionuclides is many times less (1 in 1 million).

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