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IFAS Extension

SL372

Solutions for Managing Wastewater in Florida Tomato Packinghouses[1]

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Introduction and Purpose

A large amount of wastewater is produced in Florida's packinghouses during the cleaning and sanitizing of tomatoes. High transportation costs for off-site disposal and strict surface water discharge regulations are critical issues associated with the management of this wastewater.

Florida is the single largest producer of fresh-market tomatoes in the United States. Approximately 70 tomato packinghouses in Florida pack tomatoes for the domestic market and generate 231 million liters of wastewater each year. Because of rapid urbanization and lack of wastewater disposal sites near packinghouses, most of the generated wastewater is transported for reuse in agricultural soils, particularly in nearby tomato fields. Since most Florida soils have a coarse texture, low organic matter, and a shallow groundwater table, land application of packinghouse wastewater in sandy soils may pose the risk of nutrients (especially phosphorus) and trace elements leaching to the groundwater.

The purpose of this article is to provide solutions for increasing the reuse of wastewater in tomato packinghouses in Florida. The recommended solutions should be modified as science and knowledge provide additional data to manage wastewater in tomato packinghouses.

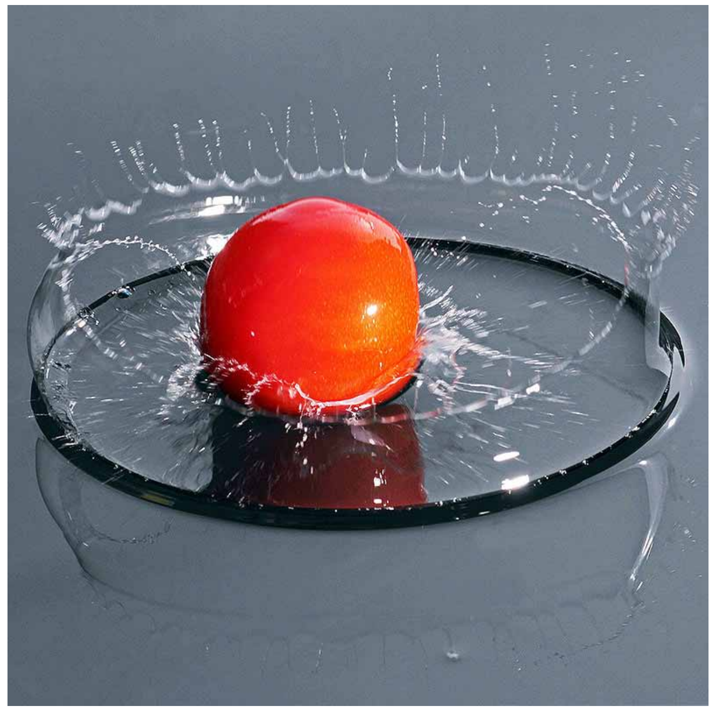

Figure 1. *Wash your vegetables* by *mcdarius*, CC BY-NC 2.0.

Tomato Packinghouse Water Use and Wastewater Production

A Florida packinghouse typically packs about 1.1 million kilograms of tomatoes a day (sixls.com/packing.php). Fresh water (city water or ground water) is used for rinsing,

1. This document is SL372, a publication of the Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. This document summarizes research funded in part by the US Environmental Protection Agency. Reviewed for accuracy and, with minor revisions for clarity, published on EDIS August 2012. Visit the EDIS website at http://edis.ifas.ufl.edu.

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washing, and sanitizing the tomatoes, which are dumped in water dump tanks (or waste stream before packing). The amount of water used depends upon the type of tomatoes. For example, the amount of water used for cleaning "round" tomatoes typically ranges from 36,000 to 68,000 liters per day, while "roma" and "grape" tomatoes require less, with amounts of water used for cleaning them varying from 3,700 to 28,400 liters per day. Most packinghouses in Florida fill their dump tanks with fresh water daily in the morning before the beginning of packing operations and replace the wastewater in the tanks at the end of the day. As a result, there is continuous recirculation of water in the dump tanks where field tomatoes are dumped and washed during a typical 6–8 hours of packing in a day. At end of a day's packing operations, approximately 3,800–18,200 liters per day of wastewater require attention. This equates to 231 million liters of wastewater each year that needs to be disposed of in an environmentally sustainable way.

Wastewater Use in the Environment

According to a survey of Florida packinghouses (Sargent, 2007), wastewater is mainly disposed in one of three ways: (a) land application in agricultural fields (54% of total wastewater), (b) discharge into sewage systems (31% of total wastewater), or (c) third-party disposal (15% of total wastewater). According to FDEP rule 62-660.805, a general permit is required for the disposal of tomato packinghouse wastewater if the volume of wastewater generated is between 19,000 and 190,000 liters per day. Packinghouses whose wastewater is produced in amounts less than 19, 000 liters per day are exempted from the requirement of a FDEP industrial wastewater permit provided discharge of wastewater meets all surface water quality standards.

Land application of wastewater in agricultural fields is a convenient method of recycling the wastewater. This use of wastewater can reduce pressure on freshwater supplies for irrigation and can provide beneficial plant nutrients and improve soil conditions. In addition, wastewater can be used to reduce the need to apply fresh water to keep the tomato farm roads navigable in dry weather.

There is, however, a lack of knowledge on the impact of land application of wastewater on groundwater with regard to contamination with phosphorus (P) and trace metals such as copper (Cu) and zinc (Zn). Further, urbanization and the close proximity of some packinghouses to Florida's sensitive water bodies is especially problematic, as the packers must comply with all regulations dealing with application of wastewater onsite or disposal of it in city sewerage systems. All these factors result in additional costs to packers. Availability of information about the various contaminants present in wastewater and the leaching potential of these contaminants when wastewater is land applied has also been lacking.

Wastewater Quality in Packinghouses

Water samples were taken from dump tanks of two working packinghouses in 2009. The chemical composition of wastewater measured at the end of packing operation showed elevated concentrations of all elements, but the magnitude of increase was much greater for some elements (for details on methods and results, see Chahal et al., 2012). Wastewater pH was in the neutral range (6.5–8.0) as recommended for Florida packinghouse dump tanks. These values suggest that wastewater is suitable for irrigating most crops without any adverse effects on crop and soil properties. The pH is also in the recommended range for Florida Class IV agricultural water use.

Electrical conductivity (EC) and chloride (Cl) were elevated in the wastewater due to the use of chlorine sanitizers in the tomato packinghouse dump tanks. Increased EC and Cl may pose moderate-to-strict restrictions for usage of wastewater as irrigation water for sensitive crops such as beans, carrot, okra, onion, and strawberry. Fortunately, most of the wastewater is not used for irrigation of these crops. The EC and Cl were higher in one packinghouse than the other packinghouse due to greater contact time of small-sized tomatoes (having greater surface area) with dump tank water.

Concentrations of iron (Fe) and zinc (Zn) were less than the threshold value (1 mg/L) for irrigation water suitability for use in agriculture. In the current study, washing of tomatoes resulted in increased concentrations of all chemical constituents in the wastewater. This suggests that the P and Cu residues (from pesticides, insecticides, and/or foliar-applied micronutrients) originating from the field-harvested tomatoes may be the likely sources of P and Cu in the wastewater. These results imply that wastewater may need to be treated with chemical amendments (such as alum, ferric chloride, lime) to effectively remove P and Cu. Another attractive and feasible option is blending wastewater with higher-quality water (groundwater, municipal water) to dilute the concentrations of P and Cu, which will also reduce levels of Cl and EC.

Risk of Phosphorus Leaching to Groundwater

Wastewater was applied at application rates of 0.84, 1.68, 2.51 cm per day (or 8,843, 17,685, 26,672 gpa [gallons per acre] per day) in packed soil columns (50 cm long × 30 cm wide). The application of wastewater at the medium rate (17,685 gpa/day) did not increase P leaching [Note that 1 gallon has 3.79 liters]. This suggests that soil-applied packinghouse wastewater may enhance soil fertility, resulting in beneficial effects on crop growth. Although the concentrations of other elements such as calcium, magnesium, and potassium in leachate (50 cm below the soil surface) were elevated in wastewater-treated columns compared with the control, these elements are not problematic in groundwater contamination. The maximum concentrations of sodium in leachate at 50 cm depth (345–358 mg/L), however, were greater than Florida groundwater cleanup target levels of 160 mg/L. The calculated sodium adsorption ratio values in leachate from low, medium, and high wastewater treatments were 1.0, 5.1, and 6.7, respectively. These values are much less than the <10 sodium adsorption ratio value of no harmful effects of irrigation water on soils, suggesting that wastewater can be safely used for irrigation. We suggest that tomato packinghouse wastewater can be beneficially land-applied at 1.68 cm/day (17,685 gpa/day) to Florida's soils (specifically Spodosols) without significant phosphorus and cation leaching concerns.

Risk of Trace Metals Leaching to Groundwater

The maximum concentrations of Cu and Zn in leachate during thirty individual leaching events were 0.30 and 0.86 mg/L, respectively. These concentrations are less than the drinking water threshold limits of 1.3 mg Cu/L and 5 mg Zn/L. Thus, there is a reduced risk of these metals contaminating groundwater.

In contrast, concentrations of Fe and Mn in leachate were greater than National Secondary Drinking Water Regulation's non-enforceable guideline values of 0.3 mg Fe/L and 0.05 mg Mn/L. Even concentrations of Fe and Mn in the control treatment were greater than these guideline values, indicating high background losses of these metals in our soils.

Among four trace metals, application of wastewater at the medium rate (1.68 cm/day, or 17,685 gpa/day) only increased the concentration of Zn in leachate at 50 cm depth, while no significant effect was observed for Cu, Fe, and Mn concentrations. On the other hand, application of wastewater at the high rate (2.51 cm/day, or 26,672 gpa/day) showed an increasing trend of Cu and Zn concentrations towards the end of the last few leaching events. This suggests that further application of wastewater may result in elevated concentrations and loadings of these metals in leachate and thus groundwater.

Data showed that a larger proportion of wastewater applied Cu was absorbed in the soil, while Fe, Mn, and Zn were removed from the soil. The strong retention of applied Cu in the soil and small concentrations in leachate suggest that risk of Cu leaching to groundwater is minimal in sites irrigated with wastewater. However, Cu is retained in the soil and may become bioavailable to subsequent crops, especially if soil pH changes towards the more acidic region. The greater background loss of Fe and Mn in our soil may be because of the enhanced mobility of reduced forms of these metals even in slight to moderate saturation conditions caused by daily irrigation events.

All these leachate concentrations were measured at the 50 cm depth, and these concentrations may further diminish with increase in soil depth because of more interaction with soil components. Based on results of our leaching study, packinghouse wastewater can be safely applied in short-term irrigation demand situations at 1.68 cm/day (17,685 gpa/day) in Florida soils (specifically Spodosols) used for vegetable production with minimal trace metal (Cu, Zn, Fe, Mn) leaching concerns. However, if wastewater is continually used on the same soil and site, it will result in potential build-up of trace metals in soil, which may cause toxicity to crops and increased risk of leaching to groundwater.

Further Reading

Detailed information about the findings of this research can be found in following peer-reviewed journal articles, reports, conference proceedings, and abstracts presented at conferences.

Journal articles

Chahal, M. K., G. S. Toor, and B. M. Santos. 2012. Characterization of nutrients and trace metals in tomato packinghouse wastewater. *Journal of Water Resource and Protection* 4:107–14.

Chahal, M. K., G. S. Toor, P. Nkedi-Kizza, and B. M. Santos. 2011. Effect of tomato packinghouse wastewater on phosphorus and cation leaching in a spodosol. *Journal of Environmental Quality* 40:999–1009.

Chahal, M. K., and G. S. Toor. 2011. Trace metal leaching in a spodosol irrigated with tomato packinghouse wastewater. *Soil Use and Management* 27:480–90.

Conference Proceedings

Toor, G. S., M. K. Chahal, and B. M. Santos. 2010. Wastewater characterization in Tomato Packinghouses. *2010 Florida Tomato Institute Proceedings*, pages 8–9. Available at http://www.floridatomatoes.org/Documents/veghort_ti_proceedings_2010.pdf.

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Conference Abstracts

Toor, G. S., and M. K. Chahal. 2010. Managing tomato packinghouse wastewater in Florida: identifying sources of metals and characterizing leaching potential. ASA-CSSA-SSSA, Madison, WI. Available at http://a-c-s.confex.com/crops/2010am/webprogram/Paper59262.html.

Chahal, M. K., and G. S. Toor. 2009. Leaching of contaminants in a soil amended with tomato packinghouse wastewater. *In* Agronomy Abstracts. ASA-CSSA-SSSA, Madison, WI. Abstract available at http://a-c-s.confex.com/crops/2009am/webprogram/Paper53149.html.

Chahal, M. K., and G. S. Toor. 2009. Nutrients and trace metals in tomato packinghouse wastewater: source characterization, leaching assessment, and remediation. *In* Agronomy Abstracts. ASA-CSSA-SSSA, Madison, WI. Abstract available at http://a-c-s.confex.com/crops/2009am/webprogram/Paper53193.html.

Reports

Sargent, S., for the Florida Tomato Committee. 2007. Options for utilization of tomato packinghouse solid waste and water: Critical issues in tomato production in Florida, A special research report. Florida Tomato Committee and University of Florida/IFAS, Gainesville.