Report for Task 2: Review of Progress on Field Research

Validating Modeling Parameters for Risk Assessment of Metals in Fertilizers

For

Pesticide Division
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By

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Executive Summary

The Oregon Department of Agriculture (ODA) set an administrative rule limiting arsenic, cadmium, lead, mercury and nickel concentrations in fertilizer, agricultural amendment, agricultural mineral and lime products effective January 1, 2003. Human health risk assessments (reviewed by Curtis and Smith, 2003) for these metals applied in phosphate fertilizers to agricultural soils provided the basis for concentration limits. In addition, some of the primary literature that provided the technical basis for risk assessments, and comments from a series of public meetings were constructive. When the administrative rule was set, a requirement was that the technical basis for it was to be reviewed in 2005. New information in the peer-reviewed literature and results of field-based research in Oregon and California were of special interest. Recent literature contained no new information on the environmental chemistry or toxicology of arsenic, cadmium, lead, mercury or nickel that influenced key elements of prior risk assessments (Curtis, 2004). Results of new field studies in California were also consistent with guidance derived from these risk assessments (Chang et al. 2004a; 2004b). Finally, information from ongoing ODA-funded research in Oregon indicated the existing administrative rule was adequately protective of human health.

It is important to continue field-based studies of accumulation/transport of metals (especially cadmium) from phosphate fertilizers in Oregon agricultural soils over the next several years. The potential impact of modest increases in metal concentrations on ecological processes, especially soil microbial communities, is much less clear than results of human health risk assessments.

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Introduction

The Oregon Department of Agriculture (ODA) set standards for arsenic, cadmium, lead, mercury, and nickel concentrations in fertilizers and related products in 2003. Development of these standards was largely based on critical evaluation of previously-conducted human health risk assessments (reviewed by Curtis and Smith, 2002). These risk assessments evaluated multiple exposure pathways for farm workers and farm families, including children. These groups were considered as those with highest exposure potential and therefore at most risk. Accumulation of metals in crops consumed in high quantities by farm families and direct consumption of soil were identified as pathways for maximum potential exposures. Estimated soil concentrations of arsenic, cadmium, lead, mercury, and nickel after 50 years of product applications an soil lead concentration after 200 years of product applications were used for exposure pathway analyses. Therefore, estimated soil accumulation rates for these metals over time were critical determinants of outcomes for exposure modeling.

Results Since 2003

Analysis of the original data incorporated into risk assessment that described metal mobility revealed more uncertainly than anticipated (Curtis and Smith, 2002). One reason for this was that laboratory experiments with metal mobility in soil and soil water inadequately represented long-term behavior of metals in the field (Strawn and Sparks, 1999). ODA therefore funded research aimed at critical evaluation of accumulation of metals from phosphate fertilizers in Oregon soils, crops, and waters. A set of field sites that represented four major Oregon agricultural regions were established and data collection was initiated in 2003. Laboratory studies of metal mobility in soils from these same sites were also initiated. While the above studies progressed well from 2003-present sufficient data for validation of modeling parameters for risk assessment were not yet available.

California funded a major research effort that evaluated accumulation of metals in agricultural soils. The scope of this was broad and allowed: (1) modeling mass balance of arsenic and cadmium in cropland soils (Chang et al. 2004a) and (2) evaluation of the roles of phosphate fertilizer and micronutrient applications in arsenic, cadmium, and lead accumulation in soil (Chang et al, 2004b). Taken together this work revealed no tendency for arsenic accumulation in agricultural soils over time (up to a 100 year stimulation period). There was a potential for cadmium increase in agricultural soils treated with phosphate fertilizer over time. The predicted magnitude was small and not likely associated with increased plant uptake of cadmium. Application of phosphate fertilizers and micronutrients were not associated with increased lead concentrations of agricultural soils. In summary, recent work from California provided no evidence that ODA administrative rules for metals in fertilizers required immediate revision.

A review of recent literature, results of large-scale field studies and laboratory work with Oregon soils revealed no basis for refuting modeling parameters used in human health risk assessments conducted for metals in fertilizers. The scientific basis for evaluation of potential ecological effects arsenic, cadmium, lead, mercury and nickel was much less rigorous. Gans et al. (2005) analyzed data on reduction on soil bacterial diversity in metal contaminated soils originally published by Sandaa et al. (1999). Sandaa et al. (1999) reported gradual elevation of soil metal concentrations over eleven years (Cadmium 0.4 to 0.6, copper 12 to 21, nickel 9 to 11, and zinc 56 to 102 mg/kg [dry wt]) decreased bacterial diversity from 16,000 to 6400 genomes/g soil [wet weight]. Gans et al (2005) applied sophisticated computational methods and estimated an even greater reduction in diversity, while total bacterial biomass was unchanged. Rare Taxa that occurred in low abundance were selectively lost after elevation of soil metal concentrations. The functional significance of loss of bacterial diversity was not determined.

Conclusions

- Information that became available after the administrative rule of 2003 was set indicated modeling parameters for previous human health risk assessments remained valid. No immediate need for revision of current limits for arsenic, cadmium, lead, mercury, or nickel was apparent.
- Significant uncertainty over metal accumulation rates in agricultural soils remained after a large California field study (Chang et al, 2004b). The ongoing field work in Oregon was designed for resolution of metal accumulation rates in agricultural soils and should continue. Models that simulated such rates estimated metal concentrations after 50, 100, or 200 years. At a minimum, validation of such estimates probably requires data over a 7-10 year time-course.
- New work (Gans et al, 2005) suggested high sensitivity of bacterial diversity to metal contamination. Future work might consider productivity of crops on Oregon field study sites or functional studies of nutrient cycling in these soils.

References

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