I. Introduction

1. Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers (1 nanometer = 1 billionth of a meter) where unique phenomenon enables novel applications (National Nanotechnology Initiative, 2014). Nanoparticles (NP) have a very high surface area relative to their volume, hence providing more reactive surface sites, which could potentially result in greater chemical reactivity and biological activity. This may reduce environmental contamination by increasing pesticide soil adsorption potential and biodegradation processes, while decreasing their release kinetics (Gogos, 2012).

2. Nanoscale iron particles are very effective for the remediation of a wide variety of environmental contaminants such as chlorinated organic solvents, organochlorine pesticides, and PCBs (Zhang, 2003). Chew et al., (1998) reported from laboratory column studies that over 98% of the atrazine was removed by iron powder within 2 days.

3. In this study, we used zero-tension, column lysimeters to characterize leaching of atrazine and bromacil, known ground water contaminants that are regulated in California, in the presence of nanoparticles under an irrigation regime known to produce percolating water in a leaching-vulnerable soil.

II. Methods & Materials

1. Study Design. The study was conducted on a bare, sandy loam soil in Fresno County, California, considered by DPR as vulnerable to pesticide leaching. The field component was conducted for approximately 34 weeks.

2. Lysimeter Design. Each unit was constructed of PVC tubing with a diameter and length of 30 cm and 120 cm, respectively. The soil, consisting of a 90 cm core was encapsulated in an undisturbed state above a 2 cm deep sand layer and stainless steel screen filter. A dome cap at the base acted as a solute-capturing reservoir.

3. Nine equipped lysimeters were installed in a single line centered two meters apart. Three replications for each of the treatments, 10% NP, 2% NP, and control, were randomly assigned to lysimeters in a completely randomized design. The Top 3 inches of the soil was removed from each lysimeter and thoroughly mixed with NPs (Fig. 1) at either 2% or 10% w/v (soil in top 3 inches of controls was removed and similarly mixed but without NP) and added back to the top of the lysimeters.

4. Chemical and Water Applications. Irrigation was provided weekly by micro-sprinklers oriented in a single line with the treatment plots. Atrazine and bromacil were applied by chemigation at a rate of 3.4 kg/ha, while potassium bromide (as a tracer for water movement) was applied with the pesticides at a rate of 100 kg Br/ha. Water was applied at a rate of 160% of ETo, which represents inefficient water applications typical of unpressurized surface delivery systems used in California (California Agricultural Technology Institute, 1988).

5. Chemical Sampling. Solute collection from lysimeter reservoirs occurred weekly and volume of extraction was noted. Soil coring of lysimeter interior occurred at conclusion of the field study. Solute and soil samples were analyzed for bromide, atrazine and bromacil.

III. Results & Discussion

1. No significant differences were observed in the volume of water extracted from the control and NP-treated lysimeter reservoirs (Fig. 2). The small particle size of NPs did not impact the water holding capacity of the soil enough to significantly affect water movement through the soil profile.

2. Movement of potassium bromide, a tracer for water movement, followed the pattern of water movement through the soil.

3. Statistically significant differences were not observed between control and NP-treated plots for the cumulative mass of atrazine (Fig. 3a) or bromacil (Fig. 3b) recovered from lysimeters reservoirs. This indicated that there was no significant effect of NP on pesticide residue movement through the soil or on the rate of residue breakdown or dissipation.

IV. Conclusions

1. Results from this study showed:
   a. Nanoparticles did not affect water movement in the soil profile
   b. Fe3O4 nanoparticles did not reduce the leaching or affect the degradation of atrazine and bromacil in the soil, likely due to their failure to increase the adsorption potential of the pesticides to the soil. This is in contrast with results from a laboratory soil column experiment where it was shown that NPs reduced the mobility of atrazine in soil (Pereira et al., 2014).

V. Future Research

1. Nanocapsules (nanoparticles containing the herbicides) have been recently developed as a carrier system for herbicides, allowing for a controlled release of the encapsulated chemical. Such nano-encapsulated pesticides protect the active ingredient from degradation processes, thereby increasing the efficiency and efficacy of weed control (Pereira et al., 2014) and providing for reduced rates of pesticide application into the soil environment.

VI. References

California Agricultural Technology Institute. 1988. Irrigation systems and water application efficiencies. CATI Center for Irrigation Technology, publication 880104. California State University, Fresno, California.


