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Effect of soil amendments on sorption and mobility of metribuzin in soils

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Abstract

Metribuzin (4-amino-6-*tert*-butyl-4,5-dihydro-3-methylthio-1,2,4-triazin-5-one), is weakly sorbed to soil therefore, leaches easily to lower soil profiles. Soil amendments play a significant role in the management of leaching losses of pesticides. Therefore, present study reports the effect of organic manure and fly ash amendments on metribuzin downward mobility in sandy loam soil columns. Application of animal manure [T-1(OM) and T-2(OM)] and fly ash [T-1(FA) and T-2(FA)] at 2.5% and 5.0% levels increased the metribuzin retention in the soil. Freundlich constant [$K_f(1/n)$] values of metribuzin for treatments T-1(OM) and T-2(OM) were 0.70 and 1.11, respectively, which were significantly higher than the value (0.27) in natural soil (T-0). The respective values for treatments T-1(FA) and T-2(FA) were 1.80 and 4.61. Downward mobility of metribuzin was studied in packed soil columns [300 mm (l) × 59 mm (i.d.)]. Both the amendments significantly reduced the downward mobility of metribuzin and affected breakthrough time and maximum concentration of metribuzin in the leachate. Leaching losses of metribuzin were decreased from 97% in natural soil (T-0) column to 64% [T-1(OM)] and 42% [T-2(OM)] for animal manure-amended columns and 26% [T-1(FA)] to 100% [T-2(FA)] for fly ash-amended columns, as metribuzin did not leach out of 5% fly ash-amended column. Study indicates that both animal manure and fly ash were quite effective in reducing the downward mobility of metribuzin in packed soil columns of a sandy loam soil.

Keywords: Metribuzin; Sorption; Leaching; Organic manure; Fly ash

1. Introduction

Presence of pesticides in ground water resources has grown in the past few years and has become an intensive and burning issue of discussion. Groundwater contamination not only affects the health of human beings as it is being directly used for drinking purpose, but also can act as a source of contamination for food chain, when used for irrigation. Metribuzin (4-amino-6-*tert*-butyl-4,5-dihydro-3-methylthio-1,2,4-triazin-5-one), a triazine herbicide, is used as selective herbicide for pre-emergence and post-emergence control of annual grasses and broadleaf weeds in sugarcane, soybean, wheat, etc. Metribuzin is weakly sorbed in soils and has potential of lateral and downward movement in the soil (Peter and Weber, 1985; Harper, 1988; Kim and Feagley, 1988; Bedmar et al., 2004). Hallberg (1989) provided a summary of several reports of metribuzin detection in the groundwater. Reports suggest that leaching of metribuzin to lower soil profiles is the main factor responsible for loss in its activity (Peek and Appleby, 1989; Mpofu, 1991).

Soil amendments can play a crucial role in the management of run off and leaching losses of pesticides. Any amendment to soil changes its physico-chemical properties, which in turn, affect the sorption, transport and degradation of the soil-applied pesticides. In soil, the organic matter and clay fractions are the major constituents which affect the sorption–desorption behaviour of pesticides (Chiou et al., 1979; Karickhoff et al., 1987).

Application of organic carbon in the form of compost, sludge, effluent and crop residues is a common agronomic

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practice followed in agriculture to increase the soil fertility and crop productivity. Generally, with increase in organic matter content of soil retention of pesticide on soil particles increases, thus, downward mobility of pesticide in soil profile decreases (Graber et al., 1997; Singh, 2003). But, application of compost can lead to a substantial amount of dissolved and colloidal organic material in the soil solution that may have an impact on the subsequent pesticide binding and transport behaviour (Graber et al., 2001). Enhanced water solubility, decreased sorption and enhanced transport resulting from the complexation or association of hydrophobic substances with dissolved or colloidal organic material have been clearly documented in both batch and column studies (Graber et al., 1995, 2001).

Now a day, fly ash, a bye-product from lignite-fired power stations, is also recommended as soil amendment in agriculture (Adriano and Page, 1981; Kalra et al., 1998, 2003). Depending upon its source of availability it may be acidic or alkaline in reaction and therefore, it can be used for the amelioration of acidic and alkali soils. Fly ash also acts as a soil modifier to upgrade the physical properties of clayey as well as sandy soils (El-Mogazi et al., 1988). It not only enhances germination of seed but, also helps in development of plant due to increased nutrient content and uptake by plants in terms of sustainable economic production. The use of fly ash in agriculture may provide a feasible alternative for its safer disposal, as in the present scenario only 32% of the total fly ash produced in India (110 mT in 2004) finds its use in the manufacture of cements, concretes and bricks and only 1% of it was used in agriculture. Generally, there are apprehensions in using fly ash in agricultural soils due to uptake of heavy metals by crops, undesirable effects on soil health and build up of heavy metal concentrations in soil after repeated use, leaching of heavy metals to ground water and health and safety of farm workers. However, extensive field trials under different agro climatic zones by Central Fuel Research Institute, Dhanbad, India have proved increased crop productivity after fly ash application in different crops without significant carry over of trace/heavy metals and radioactivity in crop produce (Kumar et al., 2000). Fly ash has also shown significant adsorption capacity for organic pollutant (Kumar et al., 1987; Konstantinou and Albanis, 2000), therefore its application to soil may have implications in reducing the downward mobility of soil-applied pesticides, especially herbicides.

Thus, soil amendments may increase/decrease the mobility of soil-applied pesticides thus, play a significant role in managing the risks of contamination of water resources. However, there is no information available on the effect of animal manure and fly ash amendments on metribuzin sorption and transport behaviour. The focus of present study was to understand the multitude of different interactions and processes that may occur in manure or fly ash amended sandy loam soil of Northern India.

2. Materials and methods

2.1. Soil

Soil used in the present study was a sandy loam soil from the experimental farm of Indian Agricultural Research Institute, New Delhi, India. Soil was collected from the surface 0–15 cm depth, dried in shade, ground to pass through 2 mm sieve and was stored in polythene bags at room temperature. The physico-chemical characteristics of the soil determined using standard analytical procedures were: pH – 7.8 measured at 1:1.25 soil to water ratio (Jackson, 1967); organic carbon (OC) content – 0.51% by Walkley and Black method (Jackson, 1967); soil mechanical fractions, sand – 78%, silt – 10%, clay – 12.4% employing the Bouyoucos hydrometer method (Black et al., 1965) and the cation exchange capacity – 11.2 cmol kg^{-1} by normal ammonium acetate (pH – 7.0) method (Jackson, 1967).

2.2. Soil amendments

Fly ash was collected from the Indraprastha Thermal Power Station, New Delhi, India. Indian coal is mainly bituminous coal that produces nearly 45% fly ash. Fly ash produced from bituminous coal mainly contains SiO_2, Al_2O_3 and Fe_2O_3. The physico-chemical characteristics of fly ash are represented in Table 1. Organic manure was locally purchased. The physico-chemical characteristics of the manure included: pH – 6.0 and OC content – 35.3%. The total carbon, nitrogen and hydrogen content of manure were determined by elemental analysis and were 38.8%, 8.8% and 4.9%, respectively.

2.3. Chemicals

Analytical sample of metribuzin (95% purity) was supplied by the Bayer India Ltd., Mumbai, India. The solvents used were of analytical grade and were purchased locally.

Table 1
Physico-chemical characteristics of fly ash

Parameter	Value
pH	6.75
Organic carbon (%)	0.17
Sand (%)	30.2
Silt (%)	50.0
Clay (%)	19.8
Heavy metals (mg kg^{-1})	
Cu	37.0
Fe	944.3
Ni	34.7
Zn	62.9
M	343.0
Pb	28.3