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Evaluation of Leaching of Atrazine and Metribuzin in Sandy Clay Loam Soil

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Atrazine and metribuzin are very effective against annual grasses and numerous broad-leaved weeds and are extensively used in agriculture in India (Sondhia, 2001). Despite of their extensive use, very little is known about their fate in Indian tropical soil. Thus, our objective was to evaluate the leaching potential of atrazine and metribuzin with representative sandy clay loam soil of Jabalpur, India.

Surface soil samples (0-20 cm) from the surrounding area of the National Research Centre for Weed Science Farm, Jabalpur, India that was never treated with any herbicide were collected, air-dried and passed through a 3 mm sieve. From the bulk soil samples, nine sub-samples of 6 kg each were placed in PVC column. Soil was sandy clay loam (clay 35.47%. silt 12.45% and sand 52.09%) with 0.80% organic carbon 0.35 mmhos/ cm CEC and 7.2 pH. Commercial grades of atrazine (50% WP) and metribuzin (70% WP) were used in leaching experiment.

The leaching experiment was conducted at Residue Laboratory of National Research Centre for Weed Science, at room temperature (32°C±2) and arranged in a completely randomised design with three replications. Polyvinyl chloride (PVC) columns (10 cm internal diameter and 60 cm long) were used in the experiment. A perforated PVC cap connected to a funnel with polyethylene tubing was attached to the bottom of the each column to collect the leachates into 500 ml flasks. Columns were sequentially filled with soil from the bottom with 3 cm of sand and 52 cm of dry soil (5.9 kg). The surface of each column was then covered with sand (3 cm) to maintain uniformity of the column surface during water application and filter paper disks were placed on top of the each column to assist uniform dispersion of the water across the column surface. Before the application of herbicides, soil columns were subjected to a 1-day saturation period followed by 1-day drainage cycle and columns were covered with aluminium foil to prevent evaporation. Atrazine and metribuzin were dissolved in deionized water and simultaneously applied to the surface of the column with a pipette at 1.0 and 2.0 kg ha^{-1} for atrazine and 0.80 and 1.20 kg ha^{-1} for metribuzin.

The addition of water was divided into 12 hourly applications of 100 ml for seven days (equivalent to 200 mm rain) so that the infiltration rate of soil would not be exceeded. A set of soil columns receiving respective amount of distilled water only served as control. Each treatment combination was replicated three times. Water eluting from the column was collected in flask and stored at -20°C for herbicide analysis. After seven days when addition of water was completed, the soil columns were allowed to drain for 36 h. The amount of water, which was drained out, was not measured. Columns were cut into two equal halves and the soil was sampled in 4 cm segments in the respective segments from all replicates and were pooled for use in analysing residues.

Detection and quantification of atrazine and metribuzin was done on CHEMITRO-1000 Series Gas Chromatograph coupled with Ni^{63} electron capture detector (ECD) with a detection limit of 0.001 μg g^{-1} and 0.002 μg g^{-1} for atrazine and metribuzin, respectively. Water samples were liquid-liquid extracted with methylene chloride and soil samples were air-dried and sieved to 2 mm and extracted with acetonitrile : water in a mechanical horizontal shaker for one hour which were then filtered and partitioned with methylene chloride. Water and soil samples were then filtered through anhydrous sodium sulfate for dehydration and then volume was reduced to 2 ml in a rotary vacuum evaporator (40°C). This final volume was transferred to silica gel column for cleanup and eluted with 50 ml of methylene chloride. Elutes were collected and concentrated on rotary

Table I. Vertical distribution of atrazine and metribuzin in sandy clay soil column at the end of the study

Soil column depth (cm)	Atrazine content (μg g^{-1})		Metribuzin content (μg g^{-1})	
	Doses			
	1.0 kg ha^{-1}	2.0 kg ha^{-1}	0.80 kg ha^{-1}	1.20 kg ha^{-1}
0-4	3.000a (47.70)	5.567a (48.34)	0.453a (12.24)	0.860a (14.69)
4-8	0.386b (5.39)	0.771b (6.19)	0.216a (6.66)	0.290b (5.29)
8-12	0.286b (3.94)	0.491b (4.59)	0.109a (3.33)	0.151b (2.76)
12-16	0.350b (4.98)	0.620b (5.69)	0.432a (13.20)	0.460b (8.48)
16-20	0.300b (5.63)	0.702b (4.81)	0.234a (7.15)	0.656b (11.96)
20-24	0.302b (5.75)	0.717b (4.85)	0.118a (3.61)	0.197b (3.59)
24-28	0.235b (4.17)	0.679b (3.77)	0.387a (11.87)	0.267b (4.87)
28-32	0.198b (3.26)	0.520b (3.19)	0.365a (11.89)	0.917a (16.74)
32-36	0.237b (2.80)	0.407b (3.81)	0.533a (16.29)	0.726a (13.25)
36-40	0.207b (5.69)	0.249b (3.31)	0.113a (3.45)	0.249b (4.55)
40-44	0.227b (1.76)	0.710b (3.65)	0.103a (3.15)	0.249b (4.54)
44-48	0.170b (4.57)	0.220a (2.73)	0.102a (3.12)	0.103b (1.88)
48-52	0.082b (1.77)	0.570a (1.32)	0.121a (3.69)	0.143b (2.57)

Within each column and for each depth means followed by similar letter are not significant according to LSD (P=0.05). Values in parentheses show per cent distribution of atrazine and metribuzin at depth of 0-52 cm.

vacuum evaporator to 1 ml and from this 0.5 μl was injected to Gas Chromatogram.

The stainless steel column packed with 10% SE-30 with 2 m length and 1/8' internal diameter was used with Column temperature : 210°C, Injector temperature 220°C and detector temperature 250°C for atrazine. For metribuzin : Column temperature : 210°C, Injector temperature 220°C and detector temperature was 240°C. Nitrogen was used as carrier gas with flow rate of 30 ml/min. Statistical data analysis was performed with the computer program GENSTATE using the ANOVA and general linear model procedure and one-way ANOVA and LSD (P=0.05) comparison were used to identify significant differences in herbicides residue content among treatments within given soil column depths.

Atrazine and metribuzin were mobile in soil columns and can easily be leached by irrigation water (Table 1). The atrazine concentration in 0-4 cm soil depth was three times higher than metribuzin. The highest concentration was found at 0-4 cm depth in atrazine and 28-36 cm depth for metribuzin. Metribuzin was distributed in all the soil depths and maximum concentration was recovered from 28-32 and 32-36 cm depths at 0.80 and 1.20 kg ha^{-1}. Peter and Weber (1985) reported that the largest part of the applied atrazine (58%) remained at the top of the column, whereas just 10% of metribuzin was found at the same depth. Southwick *et al.* (1995) reported that metribuzin had low affinity to organic carbon and therefore was more susceptible to leaching than atrazine. Atrazine and metribuzin leached down upto 52 cm depth in soil and 3.87 and 3.14% of metribuzin was recovered from the leachates at 0.80 and 1.20 kg ha^{-1} treatments, respectively. Herbicide distribution with soil depth revealed no overall difference between the two doses of the herbicides at 0-52 cm depths.

The atrazine recoveries from leachates were 1.72 and 1.41% at 1.0 and 2.0 kg ha^{-1}, respectively. Recovery of metribuzin from the leachates was higher than atrazine in both the application rates. The total recovered amount of atrazine and metribuzin (soil and leachates) from the representative sandy clay loam soil of Jabalpur was found 35 and 40%, respectively. Low recoveries of atrazine and metribuzin could be due to the results of interaction among mineralization, formation of biotic and abiotic products viz., different metabolites as well as formation of bound residues (Bedmar *et al.*, 2004). The data generated here clearly indicated high mobility of metribuzin than atrazine in sandy clay loam soil column.

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