REDUCING METHYL BROMIDE EMISSIONS FROM SOIL FUMIGATION IN GREENHOUSES

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The biocidal activities of methyl bromide (MeBr) against a wide variety of soil-borne pest are well known. Although MeBr has been listed as an ozone depleting chemical, many countries in Europe still consider its use invaluable, particularly in intensive horticulture in greenhouses. It is claimed that 33-80% of MeBr used for treating soil is currently being emitted to the atmosphere (MBTOC, 1995). If emissions can be reduced within a short time period by improvements in current practices, then a case could be argued for the prolonged use of methyl bromide. With this in mind a multi-national research programme with seven laboratories across Europe was launched in 1993 under the auspices of Methyl Bromide Global Coalition (MBGC), an international consortium of methyl bromide manufacturers and distributors, to investigate means of reducing emissions from soil fumigation.

The task for the Central Science Laboratory (CSL) at Slough was a) to determine permeabilities of sheeting materials for MeBr and to develop a method for studying emission through low density polyethylene (LDPE) and laminated sheeting during pilot and full-scale fumigations, b) to identify factors responsible for leakage in a practical situation and c) to try to establish a budget for the amount of MeBr used in soil treatment. New methods and techniques of analysis had to be developed to explore these parameters.

Fifteen sheeting materials, mostly of LDPE and some laminates made of different materials to enhance their impermeability, were tested for permeability to MeBr at 20°C and 60°C using 2.5% and 100% concentrations of MeBr gas. A modified method (ASTM 1981) using a test cell developed at CSL was used to determine the permeabilities. At least five good quality laminated sheets have been identified. "Bromotec" sheeting manufactured by LMG Smiths Brothers, UK, was one of these, having a low permeability of 0.0024 $gm^{-2}\ h^{-1}$ at 20°C. It was tested alongside commonly used LDPE sheeting of 38 micron thickness (permeability 0.36 $gm^{-2}\ h^{-1}$ at 20°C) to compare emissions, initially in 3 m x 3 m micro-plots and later in commercial glasshouse beds. With micro-plots, replicated tests were carried out using both types of sheeting materials and a dose of 100 gm^{-2}. In larger plots, duplicate fumigations were conducted using 100 gm^{-2} for LDPE and 50 gm^{-2} for Bromotec sheetings respectively.

Permeations through the films during fumigation were monitored using a device acting as a permeation cell sealed on to the surface of a sheeting. Gas concentrations were monitored using an on-line gas chromatograph fitted with a flame ionization detector, a micro-processor controlled gas sampling valve and a 32 position stream-selection valve. From the data obtained concentration-time products were calculated for each stream at the end of the treatment. Soil moisture and temperature during the tests, together with the pre and post-fumigation inorganic bromide content of the soil were also determined.

The mean inorganic bromide residues in soil samples taken after the treatment ranged from 39-74 mg/kg for micro-plots and 49.5-62 mg/kg for the bays. From a mass balance exercise about 37-50% of MeBr dosed could be accounted for from the analytical data of micro-plots (Table 1) whereas 53-77% could be accounted for from the bays (Table 2). The losses, which can be considered as the worst-case situation without any modification to the current practices other than the use of "Bromotec" sheeting, could be attributed to the substantial leakage through the edges, especially from the microplots, and some penetration of gas to a depth more than 0.3m.

It is apparent from the data collected that the emission through sheetings (average 21 gm^{-2} for LDPE and 0.70 gm^{-2} for Bromotec), although significant, is not the only factor to be taken into consideration when conducting soil fumigation with MeBr. In addition to using virtually impermeable films (VIF), improvement in sealing the edges are imperative to minimise emissions.

TABLE 1. MASS BALANCE OF METHYL BROMIDE, AS USED IN MICRO-PLOTS.

Area of micro-plots 9m^2 (a)
Estimated volume of micro-plots, 30 cm deep and 3 metres square = 2.7m^3 (b)
Dosage rate - 100 g/m^2 (c)
Total dose - 900 g (d)
Av. Soil moisture - 14% (e)
Av. wt. of soil - 1.7kg per litre. (f)
Estimated mass of soil in each micro-plot - (b x f x 1000) = 4590 kg (g)

Temperature below sheets varied between 14.5° - 26.1°C

	Plot A (LDPE)	Plot B (BROM)	Plot C (BROM)	Plot E (BROM)	Plot F (LDPE)	Plot G (BROM)	Plot H (LDPE)
Av. Concn. after 4 days' in soil g/m^3 .... h	27	26.5	36.6	29.3	13.8	3.9	15.3
Amount of MB under sheet after 4 days. (b x h) g...... i	74	72	98.8	79	37.3	10.5	41.3
Average emission through sheeting g/m^2................. j	16.9	2.2	3.86	4.04	11.7	5.04	6.97
Total emission of MB through sheeting (a x j) .... k	152	20.0	34.7	36.4	105.3	45.4	62.7
Av. Br^- residue in dry soil, mg/kg l	48	50.8	62.8	64.5	46.1	73.8	39.2
Mass of Br^- in soil $\frac{(l \times g)}{(1.14 \times 1000)}$ g .... m	192	204.5	253	260	186	297	158
Mass of MB, $\frac{(m \times 95)}{(79.91)}$ g .... n	228	243	300	308.7	220	353	188
Total MB, (i + k + n) g ....p	454	335	434	424	443	409	387
% Dose accounted for $(\frac{p \times 100}{d})$	50	37	48	47	49	45.5	43

N.B. During mass-balance calculations, the amounts of MB lost through penetration below 0.3 m of soil were not taken into consideration. Therefore, the data represent the worst-case situations.

TABLE 2. MASS BALANCE OF METHYL BROMIDE, AS USED IN FULL SIZE BAYS IN A SIX-BAY GREENHOUSE.

Area of each plot 91.8m^2 **(a)**
Estimated volume of each bay, 29.6 m x 3.1 m x 0.3 m = 27.53 m^3 **(b)**
Av. soil moisture - 16% **(c)**
Av. wt. of soil 0 1.7 kg per litre **(d)**
Estimated mass of soil in each bay - (b x d x 1000) = 46801 kg **(e)**

Temperature under the sheets varied between 9.5° - 29.4°C

	Bay 2 (BROM)	Bay 4 (BROM)	Bay 3 (LDPE)	Bay 5 (LDPE)
Dosage rate, g/m^2 .... f	50	50	100	100
Total dose, g .... g	4600	4600	9200	9200
Av. Concn. after 4 days in soil g/m^3 .... h	26.6	19.7	38.5	27.2
Amount of MB remaining under sheet after 4 days. (b x h) g i	732.3	542.3	1060	749
Average emission through sheeting, g/m^2....................... j	0.85	0.56	26.7	16.9
Total emission of MB through sheeting (a x j) g .... k	78	51.4	2451	1552
Av. residue in dry soil, mg/kg l	49.5	61.9	59.3	55.0
Mass of Br$^-$ $\frac{(e \times l)}{(1.16 \times 1000)}$ g ..... m	1997	2497	2392.5	2219
Mass of MB, $\frac{(m \times 95)}{(79.91)}$ g .... n	2374	2969	2844	2639
Total MB, (i + k + n) g .... p	3184	3572	6355	4939
% Dose accounted for $\left(\frac{p \times 100}{g}\right)$	69	77	69	53

N.B. During mass-balance calculation, the amounts of MB lost through penetration below 0.3 m of soil were not taken into consideration. Therefore, the data represent the worst-case situations.