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Protective masks assessment as tools for safety handling of selected agro chemicals during spraying

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Abstract **:** The pest and disease control is one of the major operations needed for getting higher yields in agriculture. Handling of pesticides has led to serious problems on environment and on pesticide handling agricultural workers. To prevent the operator against exposure to pesticides, the operator should wear the personal protective mask. In actual practice sprayer operators are not using these protective masks for various reasons. Therefore, a study was undertaken to evaluate commercially available five masks for their materials of construction, filtering efficiency, comforts in field usage (modified Corlett and Bishop scale) and breathing resistance was tested at Central Labour Institute (CLI) Mumbai as per BIS. The masks were found manufactured using foam pad, single and double layered poly propylene and cotton cloth as filtering materials. For preventing chlorpyriphos and endosulfan from inhaling air masks with double layered poly propylene with water repellent quality filter was found good with an average filtering efficiency of 87 per cent. Operator's opinion indicated that the mask made of flexible plastic body with cotton filter and exhale valve was giving higher wearing comfort, higher breathing comfort based on developed scale. The minimum breathing resistance was found in same mask as 0.68 m bar.

Key words **:** Ergonomics, Exposure, Masks, Protection

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The use of pesticides in agriculture is the most common way of controlling pests world-wide. Problems with the use of pesticides are usually worse in developing countries where many products which are banned are still in use. Spraying pesticides can be dangerous to humans. Pesticides may operate through hormonal or genotoxic pathways to affect male reproduction. They may penetrate the blood to potentially affect spermatogenesis, either by affecting genetic integrity or hormone production. Inhaling pesticide fumes and mists is a very common entry route of pesticides into the body. Absorption through the lungs is great and the sensitivity is high. Inhalation exposure is one of the easiest to prevent by wearing readily available adequate personal protective mask and it is generally a cheaper option. Garg (1996) studied five different types of available masks. Trials showed that operator felt uncomfortable in wearing all type of respirators. Lange (2000) stated that inappropriate use of respirators during low exposure concentrations might result in increased incidence and prevalence of disease due to physiological and psychological stress. Shaw and Abbi (2000) stated that fabrics laminated or coated with plastic or rubber film provide excellent protection from exposure. Caretti *et al.* (2006) stated that significantly decreases in performance of worker were found with increased inhalation resistances. Anne and Susan (2008) surveyed and reported that 75 people were not using any respiratory protection device for spraying due to discomfort of wearing. Keeping the above points in view, studies were conducted to evaluate the regionally available five masks for their as filtering capacity and comfort for workers. The masks were tested at CLI Mumbai for their breathing resistance.

METHODOLOGY

Commercially available eight masks used by farmers during spraying were procured and five of them were selected for study. Three same configurations with other masks were neglected.

A cubical mild steel structure of size 3.0 m x 2.0 m x 2.0m was constructed on cement floor to test the masks under uniform chemical environment as shown in Plate 1. The volume

Plate 1 : Test chamber

was 12.0 m^3. The floor area was 6.0 m^2. The four sides and the top were closed using 200µ LDPE poly house sheet. A door was provided in one of the sides.

The personal air sampling (Machera *et al.,* 2003) the PCXR4 type air sampler with sorbent tube was used to collect air samples in the test chamber The sorbent tube contains a filter to trap aerosols and a two-section sorbent bed to adsorb vapours. Pesticides samples are usually drawn at an air flow rate of 1.0 to 4.0 L min^{-1} to obtain volumes ranging from 60 to 480 L. as per test procedure. The line diagram of sorbent tube as shown in Fig. A.

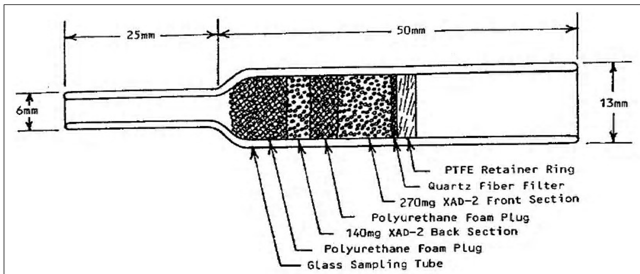

Fig. A : Line diagram of sorbent tube

Endosulfan 35EC and chlorpyriphos 20EC are the pesticides most commonly used to control different types of pests and diseases were selected for study (Regupathy *et al.*, 2003). Amount of pesticide solution required for the test chamber was calculated based on the test chamber floor area and the chemical requirement per hectare. The required spray solution was 300 ml for the test chamber floor area (Regupathy *et al.,* 2003). A calibrated aspee power sprayer was used for spraying 300 ml of spray solution into the test chamber.

The Masks were evaluated for two conditions namely sealed mask on glass plate and mask fitted on mannequin face. Sealed mask arrangement ensures 100 per cent entry of the air through the filter of the mask only and the filtered efficiency in this case was termed as absolute filtering efficiency. There will be gaps if a worker wears a mask between the face and the mask outer edge through which there are chances for the entry of unfiltered chemical air in to the nose. To simulate this condition a mask was fitted on mannequin face and evaluated and the filtered efficiency in this case was termed as actual filtering efficiency.

After pumping the required quantity of pesticides solution in to the test chamber, 240 L and 60 L of air was collected in the sorbent tube by operating the air sampler as per NIOSH 5600 (1994) and OSHA PV2023 (1988) methods, respectively. After each experiment, the test chamber was cleaned. The amount of pesticide present in the air was determined using gas chromatography.

Pesticide residue in the sample was calculated as follows.

$$\text{Pesticide residue} = \frac{A_S}{A_{St}} \times \frac{W_S}{V_I} \times \frac{V_E}{A_Q} \times 10^6 \text{ ppt}$$

where,
A_S – Sample area of pesticide
A_{St} – Standard area of pesticide
W_S - weight of standard
V_I -Volume of standard injected
V_E -Volume of sample extracted
A_Q - Quantity of air collected

Subjective evaluation was carried out in the field to determine the wearing comfort and breathing comfort and with twelve subjects as per modified Corlett and Bishop ten point scale in actual field conditions (Fig. B). The subjects were

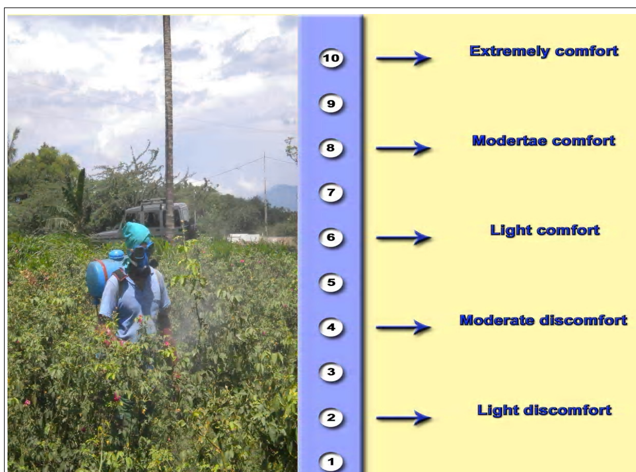

Fig. B : Visual analogue scale for assessment of wearing comfort during spraying with masks

asked to wear the masks and allowed to take rest for ten minutes. After this period they were asked to mount the power sprayer on their backs and do the spraying operation in a rose garden for 60 minutes. After that they were asked to indicate the wearing comfort and breathing comfort level on scale. Breathing resistance of the masks were tested as per IS 9473-2002, Clause5.11.

■ RESULTS AND DISCUSSION

Three types of filter materials namely cotton cloth, foam pad, and poly propylene were observed in the masks. The weight of the masks varied between 6 to 86 g. The filtering material area varied between 23.0 to168 cm^3. Specification of masks is given in Table 1.

Pesticide residue inside the test chamber after spraying was 96.4 ppt. At this level of pesticide concentration the absolute filtering efficiency for chlorpyriphos was maximum in mask M_5 *i.e.* 97.3 per cent and M_1 *i.e.* 86.0 per cent and minimum in mask M_4 *i.e.*30.0 per cent. Actual filtering efficiency of masks for chlorpyriphos was maximum in mask M_5 *i.e.* 78.1 per cent and minimum in mask M_4 *i.e.* 3.21 per cent (Table 2).

These results on protection from chlorpyriphos were statistically analyzed further using a complete randomized design analysis and values are presented in the Table 3. The type of filtering material influenced the filtering capacity significantly. The fit of the masks on the face of the operator also proved to be influencing significantly. This implies that the all the masks are not fitting the face profile perfectly, thus causing a leakage through sides. The interaction between the type of mask and the fit of the mask to face was also proven to be significant, implying that the leakage at the sides of each mask is different for each fit. The grouped mean comparison

Table 1 : Specifications of masks

Sr. No.	Mask identification no.	Filter material	Mask weight, (g)	Mask volume (cm^3)	Filtering area of the filters (cm^2)
1.	M_1	Foam pad	22	344	26.2
2.	M_2	Double layered poly propylene	10	1512	168.0
3.	M_3	Cotton cloth	86	810	113.0
4.	M_4	Single layered poly propylene	36	288	23.0
5.	M_5	Double layered poly propylene	6	969	161.5

Table 2 : Filtering efficiency of masks

Sr. No.	Masks	Absolute filtering efficiency for chlorpyriphos (%)	Actual filtering efficiency for chlorpyriphos (%)	Absolute filtering for efficiency for endosufan (%)	Actual filtering efficiency for endosufan (%)
1.	M_1	86.0	44.5	87.0	76.6
2.	M_2	54.6	46.9	77.0	22.0
3.	M_3	64.4	6.74	82.0	57.1
4.	M_4	30.0	3.21	84.3	81.7
5.	M_5	97.3	78.1	87.9	86.5

Table 3 : Anova for the protection offered by the masks against clorpyriphos

Sr. No.	Source	df	SS	MS	F	PROB
1.	Mask type (M)	4	16290.59	4072.64	959.16	0.000**
2.	Fit of the mask to face (F)	1	6787.40	6787.40	1598.53	0.000**
3.	Interaction (MF)	4	2274.36	568.59	133.91	0.000**
4.	Error	20	86.92	4.24	1.00	

c.v.=0.05

Table 4 : Anova for the protection offered for endosulfan by the masks

Sr. No.	Source	df	SS	MS	F	PROB
1.	Mask type (M)	4	129351.35	32337.83	171.31	0.000**
2.	Fit of the mask to face (F)	1	2666.08	2666.08	14.12	0.020*
3.	Interaction (MF)	4	111561.50	27890.37	147.75	0.000**
4.	Error	20	3775.31	188.73	1.00	

CV: 3.28%

by LSD proved that the mask with a filtering material of double layered poly propylene with water repellent quality (M_5), even with considerable leakage at the sides, proved to be statistically superior in terms of its protection. Looking at the mean comparison by LSD, the protection offered by the mask having filter material as foam pad (M_1) is superior when leakage is not considered. The comparison also shows that if the profile of the mask M_1 was altered to fit more closely to the individual face, the protection it offers can be improved to a large extent.

Similarly for endosulfan, the masks were tested at 467 ppt chemical concentration in air. The absolute filtering efficiency was above 77.0 per cent for all the masks. Actual filtering efficiency for endoslfan was maximum in mask M_5 *i.e.* 86.5 per cent and M_4 *i.e.* 81.7 per cent and minimum in mask M_2 *i.e.* 22.0 per cent. Mask M_5 was found with higher filtering efficiency both in absolute condition and in actual condition.

These results on protection from endosulfan were statistically analyzed further using a complete randomized design analysis and values presented in the Table 4. The type of mask influenced the filtering capacity significantly. This is obvious, since each mask has different filtering media as explained in Table 1. The fit of the masks on the face of the operator also proved to be influencing significantly. This implies that the all the masks are not fitting the face profile perfectly, thus causing a leakage through sides. The interaction between the type of the mask and the fit of the mask to the face was also proven to be significant, implying that the leakage at sides of each mask at each fit is different. The mean comparison by LSD proves that the mask with a filtering material of cotton cloth (M_3) and that with double layered poly propylene with water repellent quality (M_5) proved to be statistically superior in terms of its protection, even with considerable leakage at sides. Looking at the mean comparison by LSD, the protection offered by the mask having a filter material of single layered poly propylene (M_4) was also better when leakage is not considered. So if the profile of the mask M_4 is altered to fit more closely to the individual face, the protection it offers can be improved to large extent.

From the results (Table 5) it is observed that breathing comfort of mask M_5 was the highest rating of 6.54 on ten point scale and others were rated below average. Higher rate of breathing comfort in mask M_5 might be due to lighter weight. And also observed that the higher wearing comfort of mask M_3 with a rating of 7.16. The maximum acceptable limit of breathing resistance for masks is 2.1 m bar. Based on the breathing resistance values it is seen that all the masks are fit to wear by human beings. The minimum value was found in the mask M_2 *i.e.* 0.16m bar.

Table 5 : Comfort of masks

Sr. No.	Mask	Comfort rating	
		Wearing comfort	Breathing comfort
1.	M_1	6.66	5.45
2.	M_2	5.79	5.87
3.	M_3	7.16	5.66
4.	M_4	5.75	5.75
5.	M_5	6.20	6.54

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