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Evaluation of a portable air purifier

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SUMMARY

A portable air purifier significantly reduced mal odour in a small room. If the atmosphere was deliberately contaminated with *Serratia marcescens* the unit rapidly removed this organism. However, if incorrectly sited, the purifier could disperse organisms into the atmosphere.

INTRODUCTION

Moderately priced mains-operated portable air purifiers are becoming increasingly available. The primary purpose of such units is to remove unpleasant or harmful odours from the working environment. If such units are effective they could well improve staff working conditions in a variety of situations, an example in the hospital environment is nursing patients with malodorous wounds.

Air purifiers usually operate by recycling the room air by means of a fan through an absorbent filter system. Since turbulence will be created it is pertinent to enquire what effect air purifiers have on the content and distribution of bacteria in the atmosphere of the room in which they are installed. This paper reports a preliminary investigation into this problem; in addition the performance of an air purifier in reducing an unpleasant smell was evaluated.

MATERIALS AND METHODS

An Astecair 50 air purifier (Astec Environmental Systems Ltd, 16 Great George Street, Bristol BS1 5RH) was tested. It measures $41 \times 20{\cdot}7 \times 37$ cm and can be either wall mounted or free standing. The power consumption is 70 W and is used to drive an internal fan which draws room air through two filters covering the base of the unit, filtered air is vented from one side. The first filter is coarse for removal of gross particulate matter whereas the second filter is chemosorbent to remove odours. No information concerning pore size is available. The coarse filter requires cleaning once a week, the chemosorbent filter should be replaced every six months. The manufacturers quote an air throughput of 50 l/s and they recommend that the unit is not used in rooms having a volume greater than 70 m^3. This air purifier was installed 1·3 m above the floor midway along one long wall of a room measuring $4{\cdot}3 \times 2{\cdot}82$ m and 3·47 m high (Fig. 1). No ventilation was provided and the door was kept closed except for necessary access.

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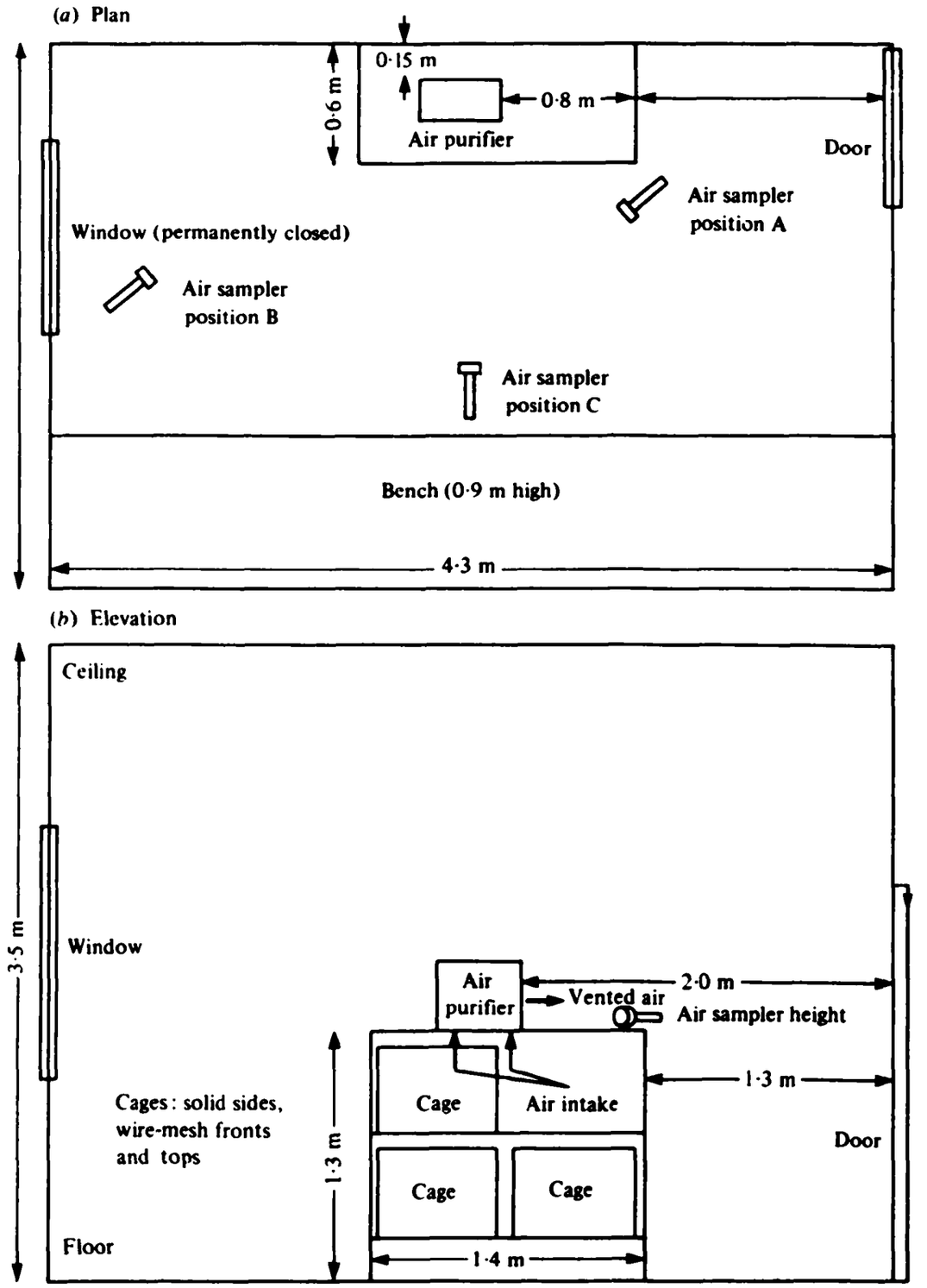

Fig. 1. Diagram showing room dimensions, location of air purifier, odour source and air sampler.

Assessment of odour was made by 12 volunteers who were asked to record their estimate by reference to a five-point scale of odour level:

1. none or very mild,
2. mild,
3. quite strong,
4. strong,
5. very strong.

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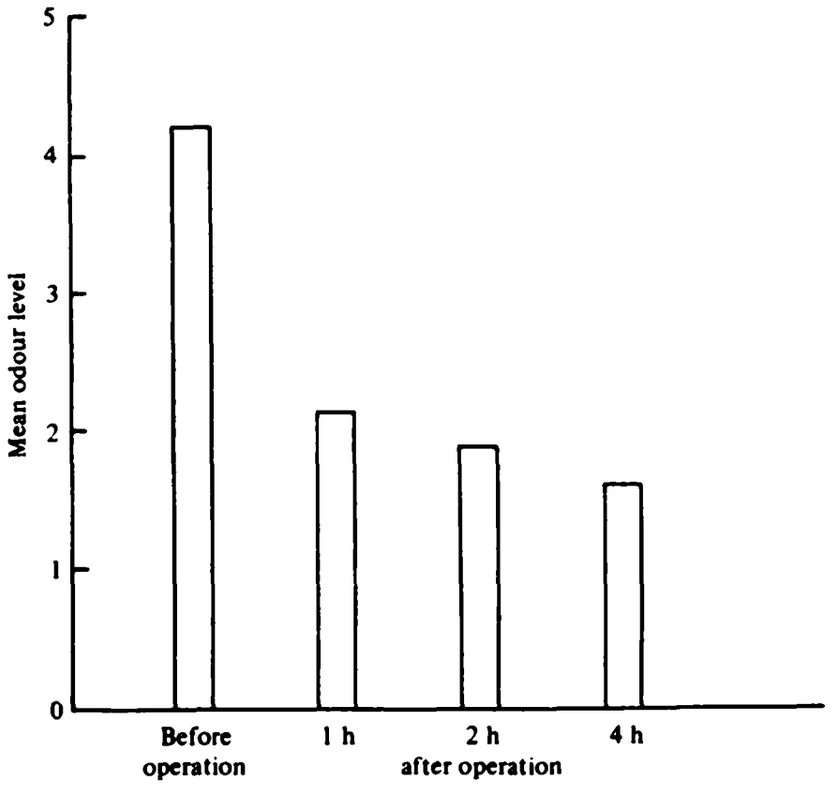

Fig. 2. Mean estimated levels of odour preceding and during operation of air purifier.

Table 1. *Duration of* Serratia marcescens *and other bacteria in room air with an air purifier in operation*

Sample	Colony-forming units	
	Serratia marcescens	Other organisms
Pre-contamination	0	62
Post-contamination	104	88
1 h post-contamination	22	346
2 h post-contamination	0	38
3 h post-contamination	0	30
4 h post-contamination	0	54
6 h post-contamination	0	24

The volunteers were told not to discuss their impressions amongst themselves nor did they know if the unit had been operating or not.

To produce a suitable odour of biological origin 12 adult guinea-pigs in three separate large clean cages which measured 60 × 40 cm were placed below the Astecair 50 (Fig. 1). The animals were provided with fresh bedding and received food and water *ad lib* but were not cleaned until odour tests were completed. Within 48 h odour of faecal material was evident in the room air. The unit was then switched on and left running overnight (18 h). After switching the unit off, the volunteers estimated the room odour; the mean score was 2·1. After leaving the unit switched off for the subsequent overnight period, the room odour was then reassessed; the mean score then was 2·9.

The cages were then cleaned thoroughly, fresh bedding provided, and left for

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Table 2. *Duration of* Serratia marcescens *and other bacteria in room air with air purifier inoperative*

Sample	Colony-forming units	
	Serratia marcescens	Other organisms
Pre-contamination	0	100
Post-contamination	20	122
1 h post-contamination	18	192
2 h post-contamination	20	156
3 h post-contamination	14	130
4 h post-contamination	40	208
5 h post-contamination	28	244
6 h post-contamination	16	138

48 h to achieve a similar level of odour as in the first experiment. The testing procedure was then reversed, i.e. the level of odour was assessed after leaving the unit switched off for the first overnight period, and on for the second; the mean scores were 2·5 and 1·7 respectively. These changes in odour level were statistically significant.

The rate at which the air purifier could reduce odour level was also investigated. Room odour was produced as described earlier and the level assessed by the volunteers. The unit was then switched on and odour level estimated by the same volunteers at hourly intervals. The results are shown in Fig. 2. The purifier reduced odour very quickly during the first hour, there was a further decline during the next two hours but this decrease was relatively small.

The following procedure was used to investigate the effect of the air purifier on bacteria present in the room's atmosphere. Air samples were taken in the room with a Biotest RCS centrifugal air sampler (Biotest-Folex Ltd, 1649 Pershore Road, Birmingham B30 3BR) directed towards the room centre at the same height above the floor as the air purifier (see Fig. 1). The quantity sampled was 80 l and the time taken was 2 min.

A gauze bandage (6 × 8 cm) was soaked with a 24 h culture of *Serratia marcescens* and allowed to dry at 37 °C for 18 h. The room was then contaminated with *Serratia marcescens* by vigorously shaking the prepared gauze for 3 min in the centre of the room. The air purifier had not been used for the previous 24 h. A further air sample was taken then the Astecair was switched on. Further air samples were taken at hourly intervals for 6 h. The results are shown in Table 1.

The test was then repeated except that dispersion of *Serratia marcescens* was obtained by holding the gauze near the outlet of the air purifier for 3 min. The machine was then switched off for the duration of the experiment. Results are shown in Table 2.

Other organisms detected were mainly aerobic sporing bacilli and micrococci, these were presumably released into the air by movement of the animals. The occasional increase in count of other organisms (e.g. Table 1, 1 h and 4 h, Table 2, 1 h and 5 h) was associated with the presence of one or two persons who entered the room for short periods of time.

Table 3. *Duration of* Serratia marcescens *in open air with an air purifier in operation. (Air sampled from various positions)*

Sample	Sample position A	B	C
Pre-contamination	0	0	0
Post-contamination	56	27	38
15 min post-contamination	25	18	21
30 min post-contamination	11	18	8
45 min post-contamination	10	5	7
60 min post-contamination	5	3	1
120 min post-contamination	0	0	0

Further tests were carried out with *Serratia marcescens* dispersed manually. The air purifier was switched on but on this occasion air samples were taken from three different parts of the room (position A, B and C; Fig. 1). The results are shown in Table 3.

Sample position A (Table 3) corresponded with the sample position used to obtain the data shown in Tables 1 and 2. The reason that the bacterial count is somewhat higher in samples obtained from position A may be due to the purifier 'concentrating' airborne organisms in the region of the air intake; positions B and C were more remote.

On one occasion the air purifier was run overnight and the two filters swabbed on both sides. The external surface yielded moderate numbers of aerobic sporing bacilli, micrococci and *Streptococcus viridans*. Similar organisms, but fewer in number, were found in the region of the interface between the two filters. Only the occasional aerobic sporing bacillus was detected on the inner surface. Inoculating the swabs into cooked meat medium and sub-culturing these after 48 h incubation did not lead to the detection of further species of bacteria.

RESULTS AND DISCUSSION

The reduction in odour following use of the air purifier was highly significant; combining the results of both tests showed that with the unit on the mean odour level was 1·9 (mild) but was 2·7 (quite strong) when the unit was not in use ($t = 3{\cdot}28$, $P = 0{\cdot}002$). The assessment of odour level by volunteers was very satisfactory though occasionally a person returned an identical score for both parts of each test (3/12 in one test, 2/12 in the other). The rate of odour reduction was reasonably rapid, a large decrease being recorded after 1 h, the level continued to decrease after this time but at a more gradual rate.

Lack of suitable cases prevented evaluation of the air purifier in a patient area but the tests with animals suggest that it might well be of benefit for patients with certain conditions. The room used for the tests had a volume of about 40000 l and the air purifier was recycling this air about 4½ times an hour. A two-bedded cubicle on the Burns Unit is about the same volume, a single-bedded cubicle somewhat less, 30000 l. In most hospitals ward areas intended for one or two

patients are not likely to exceed this volume. Clearly room size will affect the efficiency of the air purifier; the maximum volume suggested by the manufacturer is 70000 l. This volume may be too high for the unit to be beneficial as there would only be about 2¼ air changes per hour. It is pertinent to note that building regulations require a minimum of three air changes per hour for water closets not having an exterior window; extractor fans in kitchens may require a somewhat greater rate of air change to be of benefit.

Regular maintenance of the filters is obviously important. The coarse filter needs cleaning weekly and the chemosorbent filter has to be replaced approximately every six months depending on use. A visual indication of filter efficiency might be useful as the need for occasional maintenance could easily be overlooked.

It was interesting to note that the Astecair reduced deliberate contamination of the air with *Serratia marcescens* quite rapidly, separate tests showed that the natural decay of this organism was comparatively slow. Since *Serratia marcescens* is a relatively small bacterium the Astecair air purifier would presumably reduce the numbers of most other organisms introduced into the air, including potential pathogens. There was a suggestion that the total number of other bacteria present in the air was also reduced. However, it is important that such units are not used with the intention of reducing bacterial numbers during dressing changes or other procedures likely to liberate bacteria into the air because failure to rapidly remove organisms that are being continually introduced into the air combined with extra turbulence might increase the risk of wound contamination. A properly designed dressing room requires a plenum ventilation system giving a minimum of 15 air changes per hour (Lowbury *et al.* 1975). The siting of the air purifier in a patient area could also be important, the vented air from the device can readily disperse bacteria. Consequently, if incorrectly situated such that air was vented over soiled bedding, dressings or wounds it could aggravate a situation that was intended to be minimized.

REFERENCE

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