Exposure of Refuse Collectors to Dust, Fungi and Endotoxins: Health Hazards and Potential Protective Measures

H. D. NEUMANN [1], G. BECKER [2], M. LOHMEYER [3], W. MATHYS [4]

[1] Gemeindeunfallversicherungsverband Westfalen-Lippe, Salzmannstrasse 156, D-48159 Münster

[2] Institut für Abfall- und Abwasserwirtschaft, Beckumer Strasse 36, D-59229 Ahlen

[3] Mikrobiologisches Institut Dr. J. Balfanz – Dr. M. Lohmeyer, Gildenstrasse 34, D-48157 Münster

[4] Westf. Wilhelms-Universität, Institut für Hygiene, Robert-Koch-Strasse 41, D-48129 Münster

Objectives, Methods and Material

Within the framework of a number of research projects, the health hazards confronting refuse collectors through exposure to dust, fungi and endotoxins were determined and described, together with potential protective measures. The special focus was on whether the background levels to which such persons are exposed have increased as a result of developments in the separated collection of organic waste and recyclable materials. Influencing factors such as different workplaces and types of refuse, community structure, collection interval and time of year were taken into account [1, 2]. For hazard assessment, more than 900 samples were taken at refuse collectors' workplaces and analysed for the presence of respirable dust, inhalable dust, metal dust, fungi and endotoxins. Concerning the legal bases, fungi have a special status in this context. On the one hand fungi-containing dust is classified in Germany as a hazardous substance because of its sensitising effect; on the other hand it is a biological agent.

Based on the results of this study, a systematic investigation and evaluation of technical and organisational means of reducing exposure to dust, fungi and endotoxins was carried out [3, 4], with the emission concentration at rave rail level, the immission concentrations at the loader, and the reduction factor $F_{E/I}$ as a quotient of the emission and immission concentration being determined. Furthermore, loading processes were simulated at the investigated collection systems using evaporated vapour fluids to visualise the potential spread of the dust. Most investigations were carried out during the domestic refuse collection (with no separate organic waste collection). In rear-end loading systems, the focus was on the exposure of the loader, and in driver-controlled loading systems on that of the driver. The following influencing variables were covered by the investigations:

- manually or automatically controlled lifting device
- type of compaction mechanism
- intake hopper design with respect to height of rave rail and hopper depth

- lifting device closure: curtain or lid
- dust interception through suction in the lifting device area
- loading process control from the cab
- lifting device cleaning intervals

Overall, 14 parameters influencing the fungi concentration in particular were investigated. The aim was to establish technical and organisational protective measures aimed at reducing exposure and thus to minimise the risk of respiratory diseases. Two of the research projects were sponsored by the Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin).

Results

The results can be summarised as follows:

The dust concentrations determined at the Institute for Occupational Safety and Health (BIA) within the framework of the study were generally low, irrespective of the collection system. As the maximum concentration of respirable dust in the lifting device area was 2.6 mg/m³, the limiting value for respirable dust specified in Germany for risk assessment purposes, i.e. 10 mg/m³ [5], is unlikely to be exceeded, irrespective of the collection system. The maximum concentration measured at the loader was 0.78 mg/m³. The maximum concentration of inhalable dust was 0.41 mg/m³ in the lifting device area, and generally less than 0.25 mg/m³ at the loader. Only once was a value of 2.1 mg/m³ recorded in the residual waste collection within the framework of a previous measuring series [6]. The limiting value of 3 mg/m³ generally valid in Germany for inhalable dust [5] is thus unlikely to be exceeded in general.

The values for the metal dusts were measured on a person-related basis during the collection of different types of refuse with different rear-end loaders. Irrespective of these influencing variables, the measured values were mainly below the detection limit [6]. The few metal dust concentrations registered were well below the admissible limiting values (see table).

Within the scope of the cross-sectional studies aimed at investigating refuse-specific and structural influencing factors, the endotoxin levels at rear-end loaders were well below 100 EU/m³ in summer and generally below 10 EU/m³ in autumn and winter [1]. A comparison of the collection systems revealed no essential differences in the endotoxin levels recorded. No evaluation of the protective measures could be derived from them [3]. Overall, the values recorded at the loader were very low, reaching a maximum of 19 EU/m³. Even in the lifting device area, the value of 100 EU/m³ was

exceeded only once. 42 of 48 measured values were below 40 EU/m^3 [3]. This suggests that the endotoxins adhere to the total dust, which was measured in only low overall concentrations.

Under the described framework conditions, exposure to fungi was also found within the scope of the cross-sectional studies to be at a comparatively low level for refuse collectors at their workplace in the main region investigated [1, 2]; however, this can be attributed to the protective measures implemented there. The mean shift values recorded for total fungi were unexpectedly low, ranging from 10^2-10^4 CFU/m³. Although they were thus clearly higher than the background levels, the total fungi concentrations were one to two powers of ten below the levels previously reported in the literature (10^4 to 10^6 CFU/m^3) and also recorded in other areas within the framework of the present study [6]. Short-term exposure peaks during the loading operation, as determined in the laboratory, may be as high as 10^7 CFU/m³ at the loader.

Fundamentally, the driver is exposed to substantially lower levels than the loader (by at least one power of ten as a rule). However, high micro-organism concentrations may occur sporadically in the cab, admitted for example on the driver's clothing or through the opened window, or resulting from inadequate cleaning of the cab. Differences between the types of refuse in terms of exposure to micro-organisms were registered only for *Aspergillus fumigatus* and only at higher temperatures, with the highest concentrations being recorded with organic waste. The total fungi, bacteria and endotoxin concentrations revealed no significant differences. In general, the values for recyclable materials were lowest.

The medical examinations carried out in parallel [1] revealed only a small number of sick workers, which may also have been due to the "healthy worker effect" within the framework of this cross-sectional study. In view of the lack of pathological features, no correlation can be derived between exposure to micro-organisms and state of health of refuse collectors as a basis for a dose-effect relationship.

Nonetheless, a potential health hazard cannot be ruled out. However, the fungi concentration at the refuse collector's workplace can be reduced by one or two powers of ten from the level of 10^4 to 10^5 CFU/m^3 by means of the technical and organisational measures described below.

One important influencing variable in reducing the fungi concentration was found to be the control of the loading process. The effective deployment of an automatically controlled lifting device may pave the way to a pronounced reduction in exposure compared with manual operation, on account of the greater distance from the source of the emission and the shorter exposure time.

Controlling the loading process from the cab is an appropriate protective measure from the aspect of reducing exposure to micro-organisms, because the operator is isolated. However, bioaerosol admission into the cab was found to be a problem when windows or the roof hatch were open.

Comparison of rear-end loader vehicles with respect to the compaction system showed that rotating drum compaction led to a higher fungi concentration than the packer plate system. This was attributed to the constant movement, to the open connection between vehicle body and lifting device, and to the shallow intake hopper.

In addition to the compaction system, technical factors contributing to a reduced fungi concentration in the packer plate vehicle used in the field study were found to be the rave rail height, the hopper depth, the guide flap in the intake area, and the long apron in the loader area. Raising the rave rail above head level obviously provides additional screening acting as a chimney through which the bioaerosol is carried upwards if the intake hopper is located sufficiently low. Designing the intake area as a guide flap moreover minimises the free fall of the waste. In contrast, a higher rave rail in conjunction with a shallow intake hopper provided only slight protection.

A hinged lid closure for the lifting device yielded no detectable improvement in the fungi concentration on the job compared with a curtain. The closing lid obviously acts like a fan through which the bioaerosol is carried out of the lifting device.

Dust interception through suction in conjunction with a lid-closed lifting device through which a partial vacuum was generated in the vehicle body proved to have a positive effect. However, there were still abundant opportunities for improvement.

With respect to the influence of vehicle hygiene, omitting to clean the lifting device for four weeks was found in the field study to result in pronounced fungal colonisation in the intake hopper area, though without leading to markedly higher values. The standardised tests revealed a tendency towards higher emission values with an uncleaned empty vehicle compared with a cleaned empty vehicle. Although this finding merely reflects trends with respect to higher emissions in cases of poor vehicle hygiene, regular high-pressure cleaning with the lifting device being flushed out from both sides at fortnightly intervals, for example, should be a fundamental rule in the interests of health.

Conclusions

In conclusion it is to be stated that refuse workers were not found to be at greater risk when collecting organic waste than when collecting residual or domestic waste. The dust concentration at the refuse collector’s workplace is low overall, so that there is normally no risk of limiting values being exceeded. Under the described conditions, the maximum endotoxin concentration level is 100

EU/m³, but it was well below that as a general rule. What is more problematic, in contrast, is exposure to fungi at the refuse collector's workplace, though this can be reduced by taking appropriate protective measures. These include the effective deployment of an automatically controlled lifting device, resulting in a reduced exposure time and a greater distance between the refuse collector and the lifting device. One beneficial feature that should be taken into account in the future development of refuse collection vehicles and integrated into international standards is a high rave rail in conjunction with a deep hopper and a guide flap in the intake area. As an alternative or additional feature, dust interception in the intake area also has development potential as a concentration-reducing instrument. Another effective means of reducing the fungi concentration is controlling the loading process from the closed cab.

With reference to the measuring method, it is to be stated that determination of the total fungi concentration has stood the test as a reference parameter for verifying the quality of protective measures in refuse collection systems.

References:

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Hazardous substance	N	< DL	Type of refuse min	Type of refuse max	Meas.val. [mg/m³] min	Meas.val. [mg/m³] max	Limit val. mg/m³	Charac-teristics
Lead and its compounds	16	15	Res.	Recycl.	< 0.0009	0.001	0.1	R_{E1},R_{F3}
Copper and its compound	16	14	Res.	Org.	< 0.0005	0.005	1	
Manganese and its inorg. Compounds	16	15	Org./Res.	Dom.	< 0.001	0.003	0.5	
Zinc	16	14	Org./Res.	Recycl. Dom.	< 0.0001	0.003		
Chromium (total Cr)	8	8	Org./Res.	Res.	< 0.0005	< 0.003		
Chromic compounds	12	12	Res.	Recycl.	< 0.005	< 0.016	0.05	K2
Cadmium and its compounds	16	16	Org./Res.	Org./Res. Recycl.	< 0.0001	< 0.001	0.015	K2
Nickel	16	16	Res.	Org.	< 0.0005	< 0.005	0.5	K3
Cobalt and its compounds	3	3	Res.	Res.	< 0.005	< 0.008	0.1	K3
Arsenic compounds	3	3	Org./Res.	Res.	< 0.003	< 0.005	0.1	K1
Beryllium and its compounds	2	2	Recycl.	Org./Res.	< 0.0001	< 0.0005	0.002	K2
Antimony	2	2	Res.	Recycl.	< 0.0007	< 0.002	0.5	

DL = detection limit, Res. = residual waste, Org. = organic waste, Dom. = organic + residual waste, Recycl. = recyclable materials

Table: Metal dust levels recorded in the refuse collection