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Risk of infection from heavily contaminated air

by KAI GRUNNET, M.D., D.P.H., and JENS CARL HANSEN, D.V.M.¹

GRUNNET, K. and HANSEN, J. C. Risk of infection from heavily contaminated air. *Scand. j. work environ. & health* 4 (1978) 336—338. In a factory processing shea nuts the dust concentrations were found to be up to 145 mg/m³ [80 % respirable (1—5 μ m)]. Bacterial examination of the dust revealed that under the worst conditions observed a worker might inhale 350,000 bacteria per 8 h. Of these, 3,000 were *Ps. aeruginosa* and 1,500 *Salmonella* spp. of nine different types. The possible health effects of these findings are discussed.

Key words: airborne bacteria, infection risk, *Salmonella*.

Little has been done to investigate the occupational risk of working in bacterially contaminated air. The risk of infection is not restricted to the diseases normally regarded as airborne. Crozier and Woodward (6) demonstrated that it was possible to infect primates with *Salmonella typhi* through inhalation of a dose 1,000 times less than would be needed for an oral dose.

Studies have been carried out among sewage workers exposed to aerosols emitted from activated sludge tanks and trickling filters and among workers exposed to aerosols emitted during land application with treated sewage (1, 4). These outdoor studies have shown that in practice the health hazard associated with biological aerosols is low, even though the data published so far do not establish the magnitude of this risk. Consequently, an extensive prospective study was initiated among sewage workers (5).

The risk of infection from airborne microorganisms may be greater indoors

due to less dilution (10). Apart from hospitals, the degree of bacterial air contamination has been registered only in a few workplaces and industries.

Heavy bacterial contamination of air may occur in industries such as paper pulp industries; the production of vegetable oils; meat-, bone-, and fishmeal factories; and other industries processing contaminated material of biological origin (2).

Since such contamination might represent a health hazard, we decided to investigate the bacterial air contamination in an industry processing imported vegetable material in order to evaluate the risk of infection in relation to exposure.

MATERIAL AND METHOD

Dust was collected in two areas with a varying degree of dust contamination. The concentration of dust in the air was calculated after collection on a Sartorius membrane filter (0.8 μ m 160 mm) with a Sartorius Gravicon apparatus, which filtered about 30 m³ of air per hour.

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Prior to the first weighing (four decimals) the membrane filters were dried at 150°C for 3 h and cooled in an excicator containing silica gel; after sampling the filters were again dried and weighed.

The number and size of the particles were measured with a Climet particle counter (CI-252, Climet Instrument Co., Sunnyvale, Calif.), and the amount of respirable dust was calculated.

Dust for the bacteriological examination was collected under aseptic conditions into sterile bottles from shelves at heights of 1.5–1.8 m above the floor on 1 d in two areas. The shelves had been cleaned the day before collection.

Only this mixed sample was thoroughly investigated by the methods described in this report. However *Salmonella* concentrations in the same size range have been demonstrated on other occasions.

The dust was suspended in dilution water from which decimal dilutions were made. After filtration of 50 ml of either the 1:10⁶ dilution or the 1:10⁷ dilution, the number of colonies was counted on a membrane filter on the following media: teepol agar, plate count agar, King's agar B (11), Slanetz agar, mannitol salt agar (12), and on Brilliant green agar (8).

All the colonies were isolated from one plate of the following media: nutrient agar, mannitol salt agar, brilliant green agar and teepol agar. After pure cultures had been obtained, all isolates were subjected to the following tests [a modified version of the method of Bonde (3)].

Stage I: gram staining and motility, O/F-test of Hugh-Leifson, nitrate reduction test, Kovac's oxidase test.

Stage II (depending on the results of stage I): Leifson's flagella stain, indole, methyl-red, Voges-Proskauer, Simmon's citrate, glucose and lactose fermentation media, litmus milk, gelatin, coagulase, DNA-ase, hemolysis, and King's agar A and B for fluorescein and pyocyanine formation, respectively.

Some strains were also subjected to special tests, such as elevated temperature and tests for urease.

These procedures result in identification at the genus level, in some cases also at the species level.

Moreover, the most probable number (MPN) of *Escherichia coli* (*E. coli*) (11) and *Salmonella* species (7) was measured.

At the time of the investigation 3 of the 20 workers had diarrhea. Six fecal samples were collected and examined for pathogenic intestinal bacteria by the Danish State Serum Institute (3 samples) and by our laboratory (3 samples).

RESULTS

Dust examination

The concentration of dust during the work hours varied from 1.5 to 10 mg/m³ in area I and up to 145 mg/m³ in area II.

About 5 % of the dust below 1 µm, i.e., 80 %, was respirable (1–5 µm).

General bacteriological examination gave a total count of 2.4 million per gram of dust, a figure which corresponds to 3,600–24,000 microorganisms per cubic meter for area I and up to 350,000 for area II.

The predominant organism was *Bacillus* species (40–50 %). An examination of selective media disclosed the following genera and species: *Micrococcus* species, *Alcaligenes* species, *Corynebacteriaceae* species, *Erwinia* species, *Aeromonas* species, *Klebsiella aerogenes*, *Pseudomonas aeruginosa* and other fluorescent *Pseudomonas*. Frequently, yeast and fungi were also isolated.

A special examination for fecal contaminants showed a content of 1,700 coliform bacteria, 140 *E. coli*, 500,000 fecal streptococci, and 790 *Salmonella* spp. per gram of dust. The sero-fermentative typing of the *Salmonella* spp. demonstrated the presence of the following types: *S. urbana*, *S. othmarshen*, *S. johannesburg*, *S. montevideo*, *S. tennessee*, *S. bloemfontein*, *S. mbandaka*, *S. oranienburg*, and *S. schwarzengrund*.

Examination of feces

The examination of the feces failed to reveal any pathogenic bacteria.

DISCUSSION AND CONCLUSION

On the basis of our findings of bacterial concentrations and the respiration volume during light work [$13 \text{ m}^3/8 \text{ h}$ (9)], the daily dose of pathogenic and potentially pathogenic organisms can be estimated approximately as: *E.coli* 20/day, *Salmonella* 100/day, *Ps.aeruginosa* 200/day in area I and up to *E.coli* 260/day, *Salmonella* 1,500/day, and *Ps.aeruginosa* 3,000/day in area II.

Compared to the normally accepted infective doses of about a million or more, these figures are low (7).

That no pathogens were demonstrated in the feces from the workers with diarrhea could be due to the fact that the workers were recovering at the time of the sampling. However, since no new cases have been reported during the following 14 months, a connection between the inhalation of pathogenic organisms and the diarrheas seems unlikely, and the reported inhalation doses of, e.g., 100–1,500 *Salmonella* per day probably do not represent a health hazard to workers. However, the collection of dust by filtration (for weight) may give results that differ from those obtained by sedimentation (for bacteriological examinations). A particle must have an aerodynamic diameter of a minimum of $1 \mu\text{m}$ to contain bacteria. The present investigation showed only 5% of the airborne particles to be below that size; consequently no great difference in bacterial concentration can be expected between dust collected after sedimentation or by filtration.

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