

## Supplementary Materials:

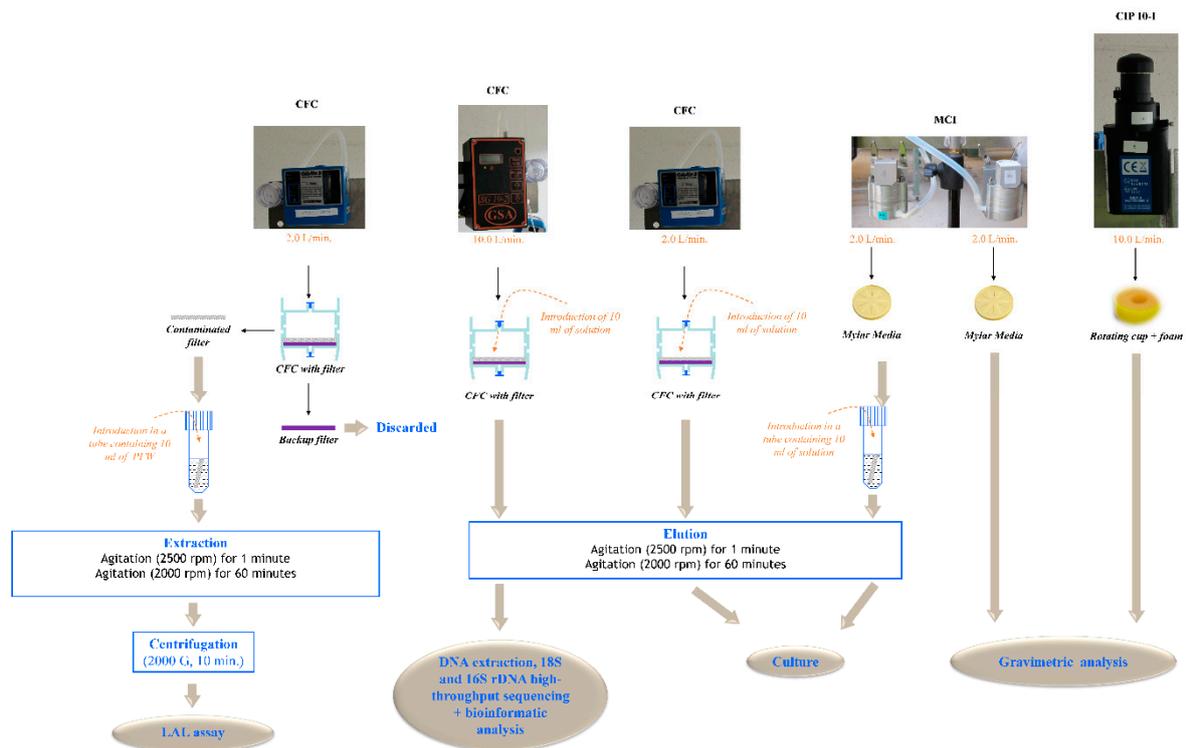
# Bioaerosol Exposure during Sorting of Municipal Solid, Commercial and Industrial Waste: Concentration Levels, Size Distribution, and Biodiversity of Airborne Fungal

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The figures and tables provided below gives additional details regarding the sorting activities as well as the methods and strategies used for sampling. Please note that

DRCIW were unloaded from dump trucks in a dedicated area (Figure 1). It comes from separate collections or from containers containing only one type of waste. It was checked, possibly manually sorted, loaded onto a conveyor belt using a grapple and then, baled using a bale press. At the exit of the baler, a mechanical loader stored the bales in a dedicated storage area. The activity employed 2 sorting operators and 3 machine operators and drivers.

Mixed DRHW was brought to the sorting center by dump trucks. It was received either in plastic bags (door-to-door collection from residents) or in bulk (collection at voluntary drop-off points) and was deposited in a dedicated large area called the "un-loading area for DRHW". A mechanical loader introduced the waste into a bag-opening hopper and the waste was then transported on a conveyor belt to a first trommel sieve. The rotating sieve drum allows sorting the waste into three main fractions. The coarsest fraction corresponded to large pieces of cardboards and torn plastic bags. It was sent to sorting cabin A (two workstations), where the operators manually removed the pieces of cardboard as well as the torn plastic bags and then, the two types of waste were sent separately to a press to be baled. A first part of the intermediate fraction corresponded to the hollow waste which included cardboard boxes for packaging, steel and aluminium metal packaging (metals beverage can and tins), plastic bottles and flasks as well as food bricks. It was discharged in a dedicated area receiving materials from cardboard sorting line and hollow wastes was from voluntary drop-off points. A mechanical loader loaded the bulk hollow waste on a conveyor belt which conveys them to a packaging sorting process. The process comprised: (i) a magnetic belt for the removal of metal; (ii) an eddy current separator for the separation of non-ferrous metal packaging (aluminium, zinc, copper, etc.), (iii) an optical sorting line which separates the plastic films and some plastic packaging from the rest of the waste stream and finally, (iv) a manual sorting step of the different plastic containers which was carried out in the sorting cabin B (4 workstations). The sorted waste was baled using a press and stored in the same building. The other part of intermediate fraction was conveyed to the "flat waste" area. Flat waste corresponds to paper, magazines, newspapers and others (flattened paper and small cardboard packaging). The area housed the flat waste sorting line that handled waste from the cardboards line. The line included mechanical sorting as well as a large manual sorting cabin (Sorting cabin C, 12 workstations.). The sorted flat waste was stored in bulk in a dedicated area adjacent to the DRCIW area.



**Figure S1.** Schematic representation of the off-line measurement process used for assessing the concentration levels of airborne culturable bacteria and fungi, endotoxins, inhalable dust as well as the biodiversity of microbial communities in bioaerosols and the size distribution of airborne microorganisms and dust in the WSP. CFC: Closed-Face Cassette; MCI: MARPLE Cascade Impactor.

| Sampling location |                                  | Description of the sampling point   | Date         |    |                                    |                         |                     |                             |   |   |   |
|-------------------|----------------------------------|---|--------------|----|------------------------------------|-------------------------|---------------------|-----------------------------|---|---|---|
|                   |                                  |   |              |    | Airborne culturable microorganisms | Airborne inhalable dust | Airborne endotoxins | Biodiversity in bioaerosols | Size distribution of aerosols and bioaerosols | Real-time measurement of airborne particles |   |
| N°                | Name                             |   |              |    |                                    |                         |                     |                             |   |   |   |
| 1                 | Unloading area for DRHW          | Device located at ground level, near the hopper. The inlet of the sampling were facing the main hall in which the loader was operating.                               | July 2014    | D1 | •                                  |                         | •                   |                             |   |   |   |
|                   |                                  |   |              | D2 | •                                  |                         |                     |                             |   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       |                     | •                           |   |   |   |
|                   |                                  |   |              | D4 | •                                  |                         |                     | •                           |   |   |   |
| 2                 | Sorting Cabin A (Cardboard)      | Device located at the bottom of the cabin and on the edge of the conveyor belt. The inlet of the sampling devices were facing the conveyor belt.                      | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   | • |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   | • |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   | • |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   | • |
| 3                 | Sorting Cabin B (Hollow waste)   | Device located at the bottom of the cabin and on the edge of the conveyor belt. The inlet of the sampling devices were facing the conveyor belt.                      | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |
| 4                 | Hollow waste area                | Device located at ground level on the periphery of the main hall of the building. Sampling inlet were facing the activity (centre of the hall).                       | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |
| 5                 | Sorting Cabin C (Flat waste)     | Device located in the centre of the cabin and in front of the main conveyor belt. The inlet of the sampling devices were facing the conveyor belt.                    | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |
| 6                 | DRCIW waste area                 | Device located in the DRCIW area. The inlet of the sampling devices was facing the conveyor belt (DRCIWdeposit).  | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |
| 7                 | Indoor reference                 | Device located in a company meeting room. The inlet of the sampling devices were facing the centre of the room.   | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |
| 8                 | Outdoor reference                | Device located outside the company, upwind. Do to different meteorological conditions, two places were chosen for the two sampling session (D1/D2 ; D3/D3).           | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |
| 9                 | Compactor for hollow waste       | Device located at ground level in the hall of the "hollow waste" building, facing the press. The inlet of the sampling devices were facing the press.                 | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |
| 10                | Cardboard area                   | Device located at ground level in the hall of the Cardboard sorting building (between the hopper and the cabin A). Sampling inlet were facing the centre of the hall. | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |
| 11                | Cabins of the motorised machines | Device located in the cab of the machines circulating in the Hollow waste Building, the unloading area for DRHW and of the grapple of the DRCIW waste area.           | July 2014    | D1 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D2 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   | October 2014 | D3 | •                                  | •                       | •                   |                             | •   |   |   |
|                   |                                  |   |              | D4 | •                                  | •                       | •                   |                             | •   |   |   |

**Table S1.** Details of the sampling plan designed for the stationary assessment of bioaerosols and airborne dust in the investigated WSP. DRHW: Dry Recyclable Household Waste; DRCIW: Dry Recyclable Commercial and Industrial Waste; Hollow waste: cardboard boxes for packaging, steel and aluminium metal packaging (metals beverage can and tins), plastic bottles and flasks as well as food bricks; Flat waste: paper, magazines, newspapers and others (flattened paper and small cardboard packaging).

| Operators                         | Description of tasks  | Date         |    | Airborne culturable microorganisms |    |    | Airborne inhalable dust |    |    | Airborne endotoxins |    |    |    |    |
|-----------------------------------|---|--------------|----|------------------------------------|----|----|-------------------------|----|----|---------------------|----|----|----|----|
|                                   |   |              |    | D1                                 | D2 | D3 | D4                      | D1 | D2 | D3                  | D4 | D1 | D2 | D3 |
| DRHW unloading area operator      | Worker involved in the surveillance of the area in general, possible manual sorting, and the regulation of vehicle traffic.   | July 2014    | D1 | •                                  |    |    |                         |    |    | •                   |    |    |    |    |
|                                   |   |              | D2 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   | October 2014 | D3 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D4 |                                    |    |    |                         |    |    |                     |    |    |    |    |
| Sorting Cabin A operator          | Worker in charge of sorting large cardboards in sorting cabin A.  | July 2014    | D1 | •                                  |    |    |                         |    |    | •                   |    |    |    |    |
|                                   |   |              | D2 |                                    |    |    |                         |    |    |                     | •  |    |    |    |
|                                   |   | October 2014 | D3 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D4 | •                                  |    |    | •                       |    |    |                     | •  |    |    |    |
| Sorting Cabin B operator          | Worker in charge of sorting hollow waste in sorting cabin B.  | July 2014    | D1 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D2 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   | October 2014 | D3 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D4 | •                                  |    |    | •                       |    |    |                     | •  |    |    |    |
| Sorting Cabin C operator          | Worker in charge of sorting flat waste in sorting cabin C.  | July 2014    | D1 | •                                  |    |    |                         |    |    | •                   |    |    |    |    |
|                                   |   |              | D2 | •                                  |    |    |                         |    |    | •                   |    |    |    |    |
|                                   |   | October 2014 | D3 | •                                  |    |    |                         |    |    |                     | •  |    |    |    |
|                                   |   |              | D4 | •                                  |    |    | •                       |    |    |                     | •  |    |    |    |
| DRCIW operator                    | Worker involved in the surveillance of the DRCIW area in general, possible manual sorting, the regulation of vehicle traffic and in charge of the operation of the compactor. | July 2014    | D1 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D2 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   | October 2014 | D3 | •                                  |    |    |                         |    |    |                     | •  |    |    |    |
|                                   |   |              | D4 |                                    |    |    |                         |    |    |                     |    |    |    |    |
| Compactor operator (hollow waste) | Worker in charge of the compactor for the hollow waste.   | July 2014    | D1 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D2 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   | October 2014 | D3 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D4 | •                                  |    |    |                         |    |    |                     |    |    |    | •  |
| Drivers                           | Drivers of the machines circulating in the Hollow waste Building, the unloading area for DRHW and of the grapple of the DRCIW waste area.                                     | July 2014    | D1 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D2 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   | October 2014 | D3 | •                                  |    |    |                         |    |    |                     |    |    |    | •  |
|                                   |   |              | D4 | •                                  |    |    |                         |    |    | •                   |    |    |    |    |
| Maintenance operator              | Worker in charge of maintenance operations for machines, conveyor belts, compactors etc.  | July 2014    | D1 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D2 | •                                  |    |    |                         |    | •  |                     |    |    |    |    |
|                                   |   | October 2014 | D3 | •                                  |    |    |                         |    |    |                     |    |    |    | •  |
|                                   |   |              | D4 |                                    |    |    |                         |    |    |                     |    |    |    |    |
| Polyvalent sorting operator       | Workers who share their workstation between sorting flat waste in sorting cabin C and sorting hollow waste in sorting cabin B.  | July 2014    | D1 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D2 |                                    |    |    |                         |    | •  | •                   |    |    |    |    |
|                                   |   | October 2014 | D3 |                                    |    |    |                         |    |    |                     |    |    |    |    |
|                                   |   |              | D4 |                                    |    |    |                         |    |    |                     |    |    |    |    |

**Table S2.** Details of the sampling plan designed for the assessment of personal exposure to bioaerosols and airborne dust in the investigated WSP. DRHW: Dry Recyclable Household Waste; DRCIW: Dry Recyclable Commercial and Industrial Waste; Hollow waste: cardboard boxes for packaging, steel and aluminium metal packaging (metals beverage can and tins), plastic bottles and flasks as well as food bricks; Flat waste: paper, magazines, newspapers and others (flattened paper and small cardboard packaging).

**Table S3.** Data of temperature and relative humidity of air at the sampling points in the investigated WSP. \* <https://www.infoclimat.fr>.

| Sampling point                   | July D1 - End |        | July D2 - Beginning |        | July D2 - End |        | October D3 - Half |        | October D4 - Half |        |
|----------------------------------|---------------|--------|---------------------|--------|---------------|--------|-------------------|--------|-------------------|--------|
|                                  | T (°C)        | RH (%) | T (°C)              | RH (%) | T (°C)        | RH (%) | T (°C)            | RH (%) | T (°C)            | RH (%) |
| 1 Unloading area DHRW            | 30.2          | 40.2   | 26.1                | 49.1   | 28.2          | 44.0   | 21.5              | 57.6   | /                 | /      |
| 2 Sorting cabin A (cardboard)    | 26.0          | 53.6   | 24.9                | 56.2   | 26.4          | 52.4   | /                 | /      | 24.9              | 64.7   |
| 3 Sorting cabin B (hollow waste) | 28.3          | 44.0   | 26.9                | 47.8   | 28.1          | 45.5   | /                 | /      | 23.2              | 65.0   |

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|    |                              |      |      |      |      |      |      |      |      |      |      |
|----|------------------------------|------|------|------|------|------|------|------|------|------|------|
| 4  | Hollow waste area            | 27.0 | 47.8 | 26.5 | 51.2 | 28.3 | 46.3 | /    | /    | 22.8 | 62.6 |
| 5  | Sorting cabin C (flat waste) | 30.5 | 43.0 | 24.0 | 48.0 | 26.6 | 45.3 | 21.6 | 59.8 | 22.9 | 66.0 |
| 6  | DRCIW waste area             | 29.0 | 46.0 | 26.7 | 48.8 | 31.3 | 38.0 | 22.7 | 54.0 | /    | /    |
| 7  | Indoor reference             | 29.8 | 43.3 | 26.8 | 48.1 | 31.7 | 40.0 | 24.6 | 50.5 | /    | /    |
| 8  | Outdoor reference            | 30.0 | 43.4 | 27.9 | 49.3 | 32.2 | 33.5 | 20.2 | 62.5 | 21.6 | 67.2 |
| 9  | Compactor for hollow waste   | 27.1 | 46.5 | 26.5 | 50.4 | 28.7 | 44.7 | /    | /    | /    | /    |
| 10 | Cardboard area               | /    | /    | 25.6 | 51.5 | 27.6 | 49.4 | /    | /    | 24.2 | 62.3 |
|    | City local weather station * | 28.3 | 56.0 | 26.0 | 48.0 | 28.8 | 41.0 | 20.8 | 61.0 | 21.4 | 64.0 |

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