Analysis of Suspended Particulate Matter in a Conventional Seed Spices Cleaning and Grading Industry: a case study of Unjha vicinity in Gujarat, India

ABSTRACT

A large number of seed spices (Cumin, Fennel, Coriander, Fenugreek etc.) cleaning-grading units are situated in Gujarat and Rajasthan. In-plant study was performed in such a cleaning-grading industry located at Unjha (Gujarat) in collaboration with Centre for Research on Seed Spice (SDAU), Jagudan, Mehsana. Apprehension for wellbeing of workers of such dust/ suspended particulate matter (SPM) generating industries are growing with time. SPM samples were collected using standard High Volume Sampler and these samples were analyzed for their respirable suspended particulate matter (RSPM) and total SPM concentration (µg/m^3). The highest concentration of RSPM (< 10 micron) inside the plant was found to be 20 x10^3 µg/m^3, while the highest SPM concentration level was 168x10^3 µg/m^3. The average particle size of SPM was 1.96 µ to 9.43 µ while that of RSPM was 1.7 µ. The Ambient air quality norms prescribed by Central Pollution Control Board (CPCB) for industrial areas limit these values to 100 µg/m^3 (SPM) and 60 µg/m^3 (RSPM). Such highly polluted in-plant atmosphere of seed spices cleaning-grading industry may cause severe health problems, leading to respiratory diseases among the workers. In order to protect the health of workers engaged in these industries, it is suggested to install the electrostatic precipitator (ESP) device and retrofitting of existing equipment (such that dust levels are within permissible limits) may be considered.

Keywords: Air Pollution, Air quality, Suspended particulate matter, Respirable particulate matter, Seed spices, high volume sampler, Spice industry.

1. INTRODUCTION

Being the production catchment area of seed spices, large numbers of seed spice cleaning-grading units are located in Gujarat & Rajasthan. Only in Unjha town of Mehsana (Gujarat), 80-90 units of seed spice cleaning-grading are under operation each having plant capacity approx. 5000 kg/hour. The raw materials received by these units contain fine dust in addition to long fiber shaped dust particles. Fine dust also includes the soil particles which mix with the spices in the fields, owing to wind or rain action. Other fine particles originate from weeds/ insects or are produced from spices themselves by abrasion during handling and storage. Because of uncertain behavior of wind/ rain action, levels of weeds/ insects and handling it is very difficult to reliably predict the kind and amount of impurities/dust in any particular batch of raw materials delivered for cleaning and grading purposes to these traditional cleaning-grading units.

Numbers of personnel are engaged in these cleaning-grading units and their health may be affected by the particulate matter emitted from these units. The food and agricultural industries are one of the major contributors of particulate emission, because of light weight and dry condition in which various unit operations, such as cleaning, grading, sieving are done. Particulate matter is made up of minute solid particles or liquid droplets that are so tiny that breathing them in can have a major detrimental effect on the health of a person [1; 2]

The particulate matter enters the human body mainly via the respiratory system, thereby causing respiratory diseases. A medical research on deleterious/ toxic effects of feed grain dusts, revealed that many individuals experiences bronchial or allergic reactions after exposure to feed and grain process dusts [3]. Analysis of dust samples of corn and groundnut processing plants, wheat flour mill and convenience food factories were found to contain various microflora that may cause occupational diseases [4; 5; 6]. Literature related to the environment pollution, caused by the seed spice cleaning grading units is rather scanty.

Ambient air quality standards prescribed by CPCB (Table 1) are notified by Government of India. In case of spice cleaning/ grading industries only particulate matter is relevant.

No systematic study appears to have so far been conducted to assess the level of suspended particulate matter (SPM) in Indian seed spice cleaning-grading industries. Before any appropriate recommendations are made to the regulatory agencies for pollution control or to the manufacturer for modification and alteration in machines and systems to reduce pollution, it was considered imperative to undertake a systematic study to determine the SPM in the plant atmosphere.

2. MATERIALS AND METHODS

A representative seed spice cleaning-grading industry located in Unjha industrial area of Mehsana district (Gujarat), was identified for the study. The layout of the plant with different zone of operations is shown in Fig.1. During the in-plant study, two units were under operation. The units of the plant with machinery nomenclature and different points of dust-sample collection are shown in Fig. 2. The concentrations of the SPM in the in-plant atmosphere of the seed spice cleaning-grading industry were assessed using a high volume sampler (APM 410, Environtech, Delhi, India) as shown in Fig. 3. Dust samples were collected at the height of approx. 1.2 meter from the ground level. The high volume sampler was run for 1.5 to 2.5 hours at one point and then moved to next point for sample collection.

The high volume sampler consists of an aspirator, a face plate to mount filter paper, a shelter hood, current stabilizer cum timer and manometer for air flow measurement. The glass microfibre filter paper

(GF/A, Whatman, Wisconsin, USA) was exposed to light source and inspected for any damage/ pinholes, etc. The filter paper was then weighed using weighing balance (Model-CX 265, Citizen Scale). The equipment was dedusted properly prior to its use. The filter paper was mounted under the face plate and the nuts of face plate were tightened. The U-tube glass manometer, filled with water, was read, prior to starting the aspirator, for correction, if any. The shelter hood was closed and the unit was run for 5 minutes. The time and date of sampling were recorded and the timer was set for desired duration and equipment was switched on. The manometer reading, i.e. water level in both the arms, was observed at 15 minute intervals and noted. When the air flow rate reached 1 m^3/min, i.e. the pressure drop reached below 35 mm, the equipment was switched off and the time elapsed noted. The filter paper was removed, folded and taken back to laboratory. The filter paper was kept in hot air oven, maintained at 105°C, without unfolding for one hour. It was then cooled in desiccator for 15 minutes at room temperature. It was then again weighed. The average pressure measured by the manometer was used to find out air flow rate from the calibration curves provided by the manufacturer of the equipment as shown in Fig. 4. The concentration of dust (µg/m^3) was measured using following equation:

Concentration of dust = $(W \times 10^6) / (V \times T)$ µg/m^3

Where V= air flow rate (m^3/min), W= mass of dust collected (g) and T= Total time of operation, minutes

The particle size analysis was carried out in a particle size analyzer (Masterizer 2000, Malvern Instrument, U.K.) for particle size <10 µ, particle size >10 µ, average particle size of SPM and RSPM.

The observations for SPM were taken at different points (representing the entire plant premises) as shown in Fig. 5A.

3. RESULTS AND DISCUSSION

The concentration of SPM varied between 16x10^3 µg/m^3 to 168x10^3 µg/m^3 at 16 related points. Highest SPM was recorded around the ambience of bucket elevator, screen and specific gravity separator (49 x10^3µg/m^3, 168 x10^3µg/m^3, and 138 x10^3µg/m^3 respectively). The respirable SPM around the ambience of these equipment was 12 %, 20 %, and 19 % as shown in Fig. 5A & 5B.

The average particle size of SPM was in the range of 1.96 µ to 9.43 µ. The average particle size of the respirable SPM was found to be 1.7 µ, while the range of particle size of respirable SPM in cumin cleaning-grading industry was 0.91 to 2.48 µ (Table 2). Particulate matter larger than 50 micron settled quite easily and cause little problems. However, the particles of 0.5 to 2.0 micron size damage the respiratory tract due to adhesion of the particles in the tract [7].

The major dust generating equipment in seed spice cleaning-grading industry appear to the conveying equipment (bucket elevator), screens and the specific gravity separator. In conveying equipment, the rubbing action of the raw-material with the buckets creates fine dust particles. Dust is generated at the transfer points of the enclosed conveying, carried through bucket elevators and emitted at the discharge end of the conveyor. Dust is also generated because of the reciprocating/ vibrating action of the sieves of the screening unit and the table of specific gravity separator. The plant area around to these machinery is not properly enclosed. Consequently, the dust from these machinery proliferates the in-plant environment.

SPM levels were substantially higher than the prescribed limit (100 µg/m^3) specified by the National Ambient Air Quality Standard of Central Pollution Control Board [8]. Similarly, the observed values were also higher than the primary (75 µg/m^3) and the secondary (60 µg/m^3) standard fixed by Environmental protection agency (EPA) of the United States of America [9].

4. CONCLUTION

The results of this study suggest that such highly polluted in-plant atmosphere may cause severe health problems, leading to respiratory diseases among the workers. In order to protect the health of workers appropriate measures like installation of ESP and retrofitting of existing equipment (such that dust levels are within permissible limits) may be considered.

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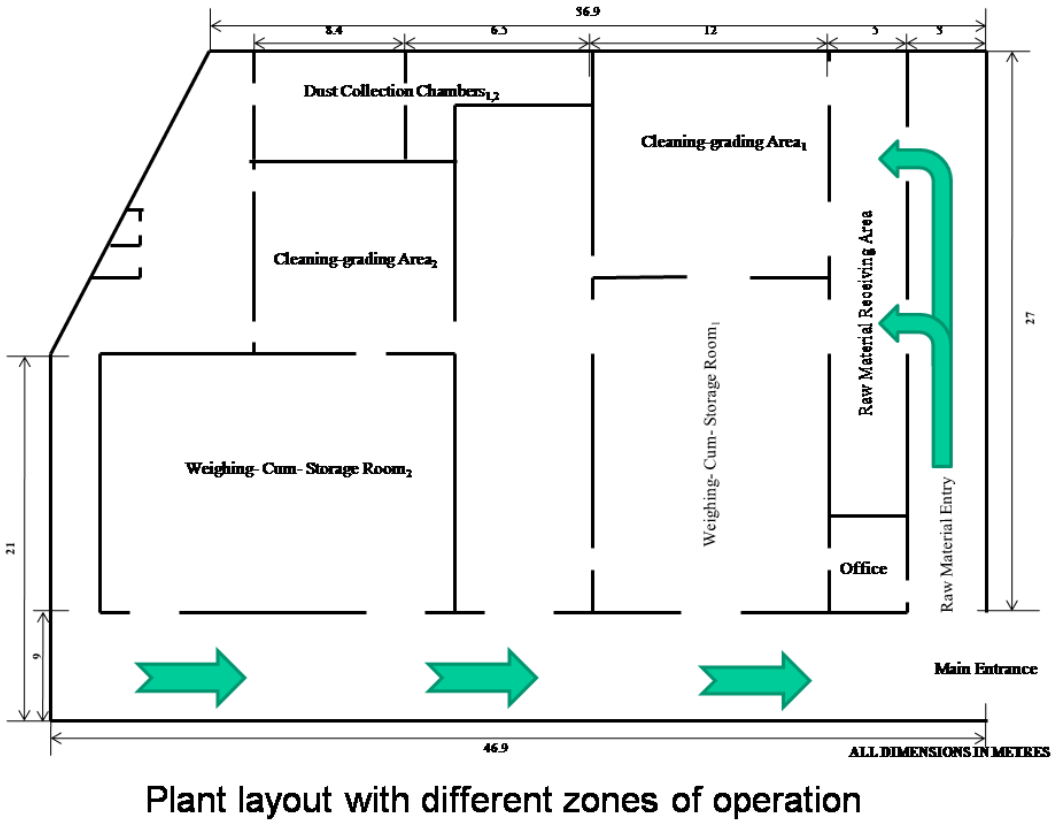

Fig.1. Plant Layout with Different Zones of Operation

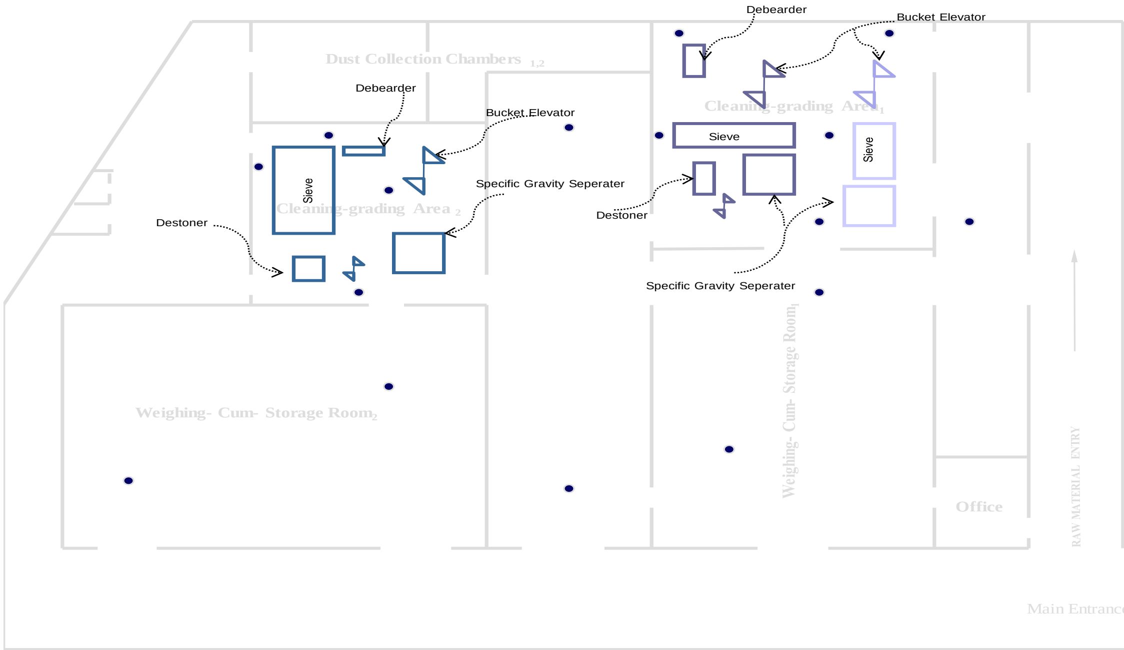

Fig.2. Plant Layout with Machinery and Points of Observation for Dust-Sample Collection

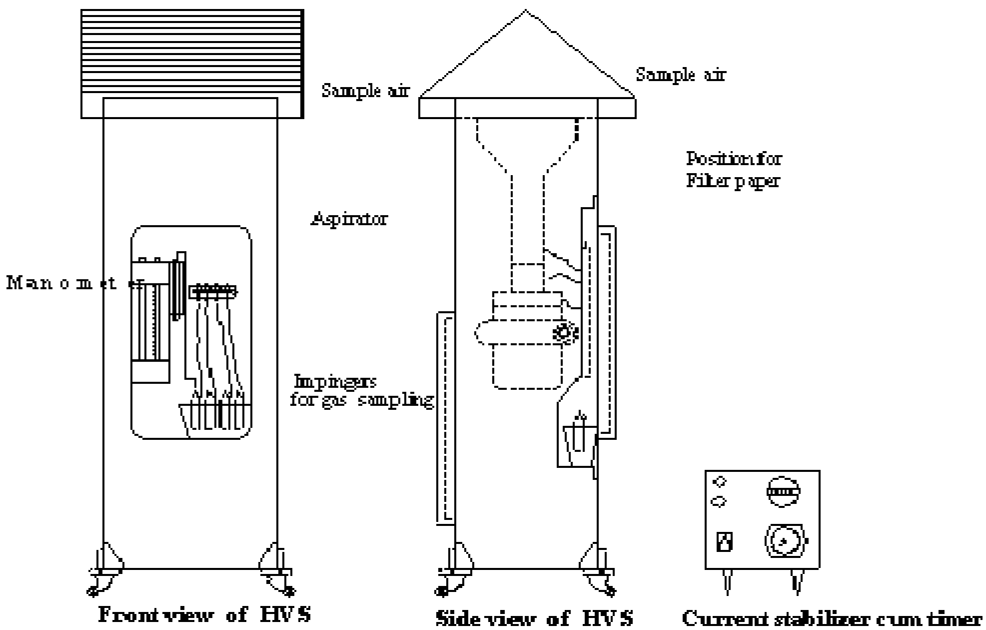

Fig.3. High Volume Air Sampler

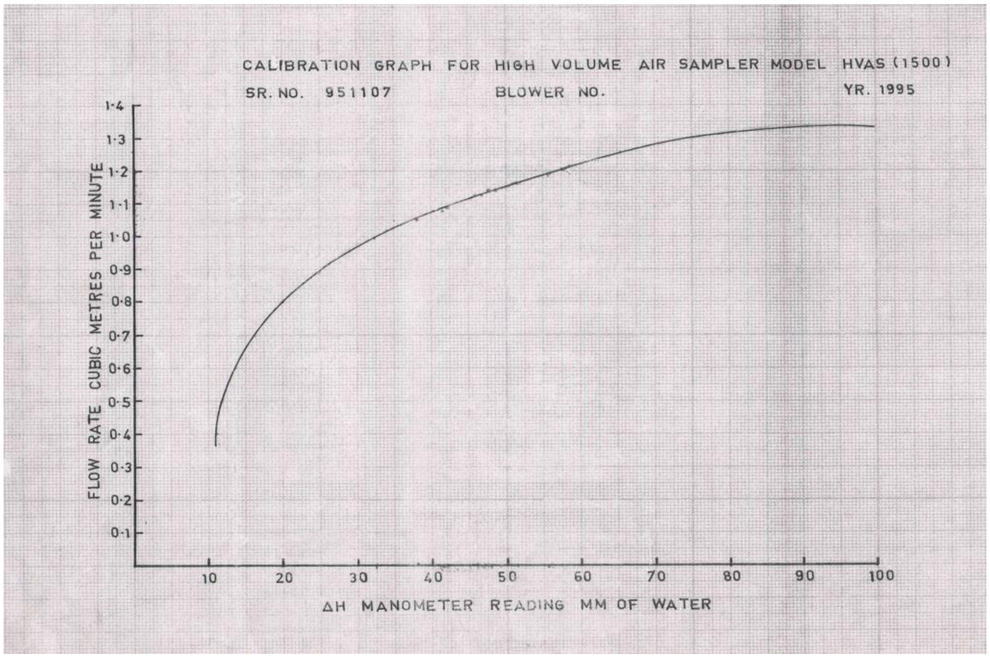

Fig.4. Pressure drop (ΔP) v/s air flow rate curve

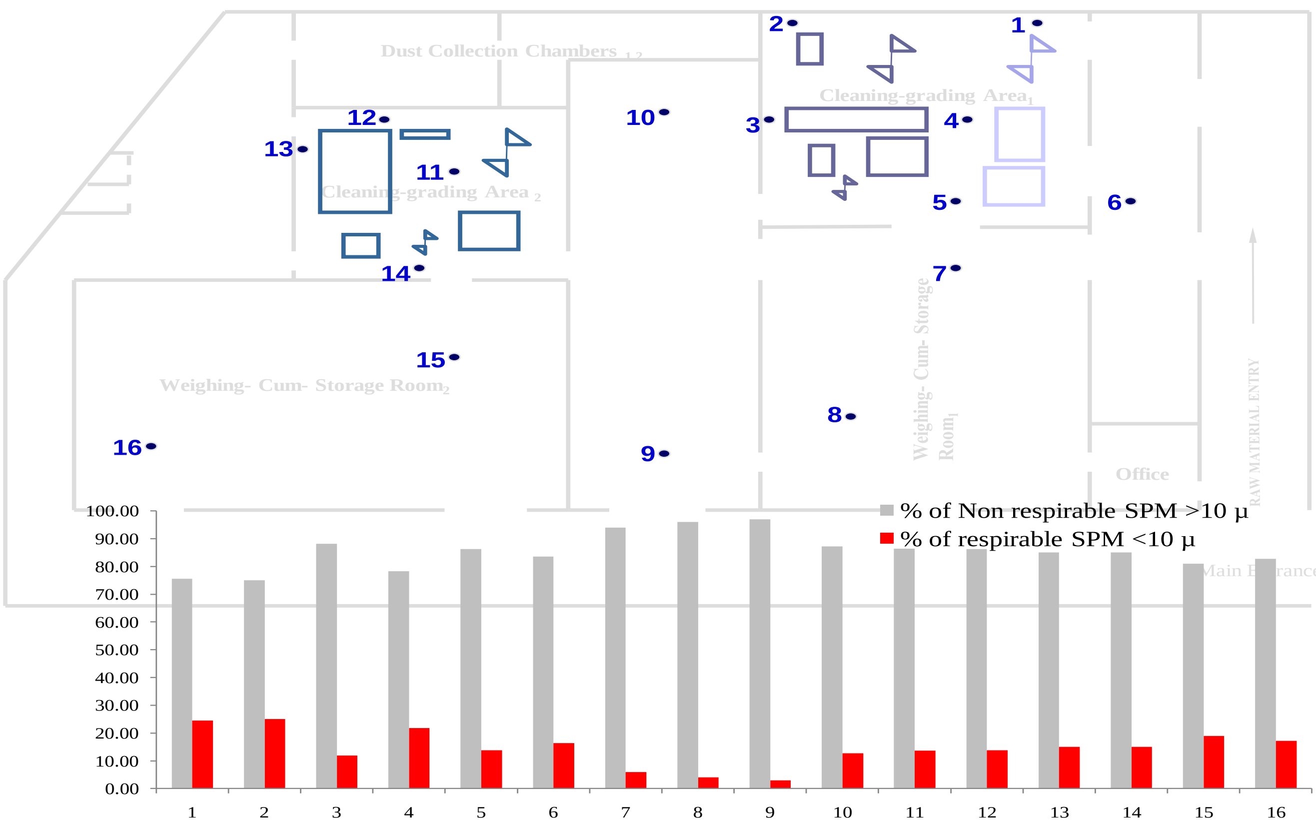

Fig. 5(A). Percent of Non respirable and respirable SPM level vis-a-vis points of observation

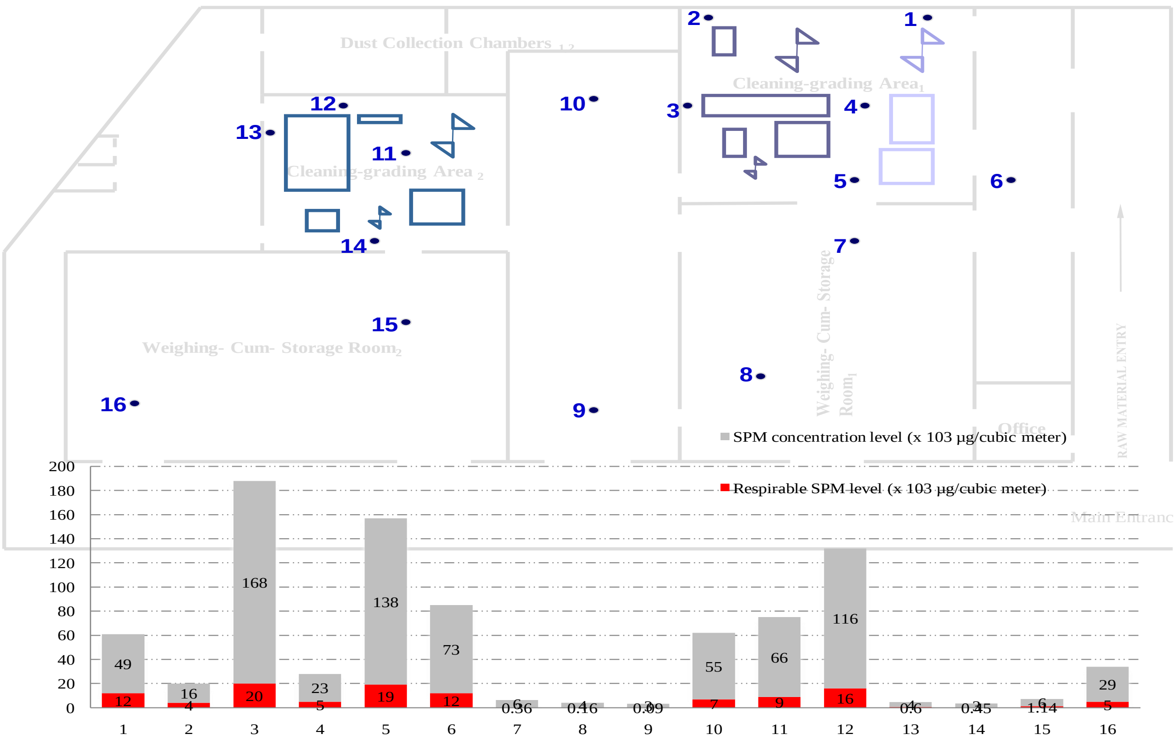

Fig. 5(B). Respirable and total SPM level vis-a-vis points of observation

Table 1. National Ambient Air Quality Standards (Anon, 2009)

Pollutant	Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area
Sulphur Dioxide (SO_2)	80 µg/m^3	80 µg/m^3
Oxides of Nitrogen as NO_2	80 µg/m^3	80 µg/m^3
Suspended Particulate Matter (SPM)	100 µg/m^3	100 µg/m^3
Respirable Particulate Matter (Size less than 2.5µm) (RPM)	60 µg/m^3	60 µg/m^3

Table 2. Proportion (%) of particles of various size ranges in dust samples collected from different points of observation during in-plant study

Particle Size	Point of Observation*															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0.49-1.06 µ	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.50	0.00	0.00	0.00	0.00	1.30	1.54	0.00
1.07-1.95 µ	0.57	0.00	0.25	0.45	0.29	0.41	0.00	0.26	0.02	0.30	0.32	0.19	0.32	1.71	2.04	0.34
1.96-3.09 µ	2.41	2.48	1.24	2.05	1.44	1.76	0.51	0.34	0.25	1.39	1.50	1.24	1.56	1.82	2.26	1.59
3.10-4.19 µ	3.04	3.17	1.56	2.57	1.83	2.19	0.93	0.74	0.22	1.73	1.88	1.75	1.98	1.77	2.22	2.00
4.20-4.88 µ	2.14	4.72	1.12	1.82	1.29	1.49	1.35	0.22	0.35	1.21	1.30	1.28	1.37	1.08	1.36	1.39
4.89-10.48µ	16.98	13.29	7.58	14.23	9.32	10.45	3.13	2.40	1.53	8.32	9.28	9.86	9.41	7.23	9.48	10.33
<10.48 µ	25.15	23.66	11.75	21.13	14.17	16.31	5.92	3.96	2.87	12.95	14.28	14.32	14.64	14.91	18.90	15.65

> 10.48 µ	74.85	76.34	88.25	78.87	85.83	83.69	94.08	96.04	97.13	87.05	85.72	85.68	85.36	85.09	81.10	84.35
Lowest Particle Size (µ)	0.91	2.48	1.06	0.91	1.06	0.91	1.06	1.06	0.49	1.06	1.06	1.06	1.06	0.49	0.49	1.06
Highest Particle Size (µ)	120.7	409.5	190.8	140.6	190.8	163.8	163.8	190.8	163.8	259	190.8	140.6	190.8	351.5	163.8	163.8
Average Particle Size (µ)	9.43	3.89	1.96	3.54	2.37	2.71	2.48	2.24	2.95	2.15	2.38	2.42	2.44	2.31	2.95	2.62

**refer to figure 5A & 5B*