EXPERIMENT 15 DETERMINATION OF DUSTFALL, RAINFALL AND HUMIDITY

Structure

15.1 INTRODUCTION

So for, you have done various experiments related to the analysis of water. Here onwards, you will study about the determination of various parametres associated with gaseous emissions. This experiment is sub-divided into three parts *viz. determination of dustfall*, *rainfall* and *humidity*. The details of the determination of each one of them are given in separate sections. Go through them carefully before actually performing the experiments. Record the observations at the appropriate places and report the results. You are strongly advised to follow the precautions.

Objectives

After performing this Experiment you should be able to:

- explain dustfall and dustfall rate,
- describe how is dustfall rate measured,
- discuss the presence of total insoluble matter, total soluble matter, volatile matter etc. and its measurements
- explain the working and installation of the raingauge,
- discuss measurement of rainfall using raingauge, and
- describe the measurement of relative humidity.

15.2 DETERMINATION OF DUSTFALL

Dust comprises solid particles larger than colloidal size which are capable of suspension in air. **Dustfall** is a particulate sample collected after air borne particles settle by sedimentation into dustfall collectors. Though dustfall measurement is crude, the information obtained is useful. The measurement indicates the concentrations of larger particles, having appreciable settling velocities, for a short period in the atmosphere. Also, it indirectly indicates the amount of pollutants emitted from stacks.

Dustfall measurement is simple. The cost of equipment for collection and analysis is very small. It consists of a collector made of glass / plastic / stainless steel which is cylindrical in shape with diametre not less than 15 cm and height not less than 2 to 3 times i.e., 30 to 45 cm, with flat bottom and open top. A suitable grill is provided as shown in Fig. 15.1.

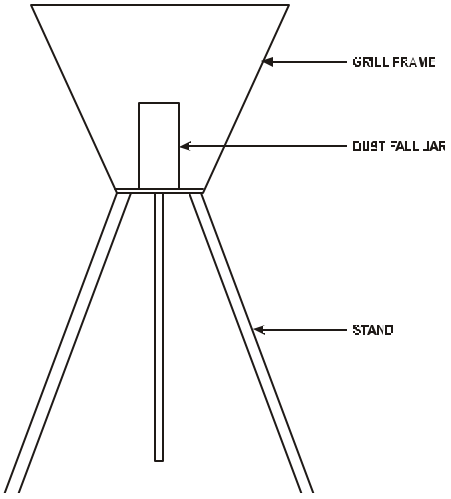

Fig. 15.1: Dust Fall Jar

Sieves of No. 18, 20 are needed for filtering the collected sample for further analysis.

15.2.1 Procedure

Take distilled water in the collector to atleast half of its volume. Suitable fungicides and algicides (traces) are added during summer period (1 cm^3 of copper sulphate solution from the stock solution containing 1 dm^{-3} of $CuSO_4.5H_2O$).

Place the collector in the grill frame. By frequent inspection of the site, take care that the collector neither becomes dry nor overflows during rainy season.

After the exposure period (one calendar month) is over, transfer the collector to the laboratory with the sample. The sample should not be transferred from the collector at the site.

15.2.2 Analysis

(i) pH is determined using pH metre.

(ii) Total insoluble matter

The sample is sieved through the No. 18 or No. 20 sieve into a suitable graduated cylinder. Using a rubber policeman, remove the particles from the walls of the sampling collector and wash them into the sieve with water using a wash bottle. Add the washings to the total volume in the cylinder. Adjust the volume to 500 cm^3 with water. Discard the residue on the sieve.

Transfer the contents of the cylinder to a beaker capable of holding approximately twice the volume of liquid present. Carefully wash and transfer any material left in the cylinder to the beaker. A rubber policeman can be used to dislodge particles clinging to the cylinder walls. Heat the contents of the beaker to the boiling point and while hot, filter through a previously dried and weighed Whatman No. 41 filter paper (W_1).

Rinse the beaker with hot water and filter. The filtrate is preserved for the determination of water solubles. The filter paper is dried in hot air oven (105ºC) and then weighed (W_2).

Total insoluble matter = $(W_2 - W_1)$ g

(iii) Inorganic insoluble matter

Ignite the filter paper along with the residue in a pre-weighed silica crucible (W_3) at 600ºC for 15 minutes and cool in a desiccator. Determine the weight (W_4) of the crucible with ash content.

Inorganic insoluble matter = (W_4 - W_3) g

(iv) Volatile insoluble matter

This is calculated as follows:

Volatile insoluble matter = (Wt. of total insoluble matter) – (Wt. of inorganic insoluble matter) g

(v) Total water - soluble matter

Make the filtrate obtained while analysing for insoluble matter up to one litre in a volumetric flask with distilled water. Take a suitable aliquot (about 100 cm^3) to determine the amount of soluble salts. Transfer the aliquot to a preweighed (W_5) borosilicate evaporating dish. If fluorides or caustic materials are suspected to be present, use a platinum dish. Evaporate the sample slowly on a hot plate until the volume is reduced to about 25 cm^3. Further evaporate the sample completely on a steam bath at a temperature not more than 99°C. After the evaporation is complete, transfer the dish to a hot air oven and keep for two hours. Cool the dish in a desiccator and weigh it. Again, keep the dish in hot air oven for 1 hour, cool and weigh again. Repeat the procedure till a constant weight (W_6) is obtained.

$$\text{Total Water solubles} = \frac{(W_6 - W_5)\times 1000}{\text{Volume of the aliquot taken in the dish}\,(cm^3)}\ \text{g}$$

Total inorganic material = (Total water solubles + Weight of the inorganic insolubles) g

Total dust '*X*' =Weight of total insolubles + Weight of total water solubles = --------g

(vi) Dust-fall Rate

The dust-fall rate is calculated as follows:

Total dust = X g = $\frac{X}{10^6}$ metric tonnes

Diametre of Jar (collector) = D cm

Area of Jar = $\frac{pD^2}{4} = A\ cm^2$

$= A / 10^{10}\ km^2$

Dust-fall rate = $(X / 10^6) \times (10^{10} / A)$

$(X \times 10^4) / A$ MT/km^2/exposure period (30 days)

If this exposure period is different, then calculation for 30 days may be done as follows:

$$\text{Dust-fall rate for 30 days} = \frac{\text{(Dust-fall rate for exposure period)} \times 30}{\text{exposure period}}$$

It is suggested that the same type of Jar be used at all stations during the network programme so that the factor '*A*' is constant. Hence, in the above equation, $10^4/A$ becomes a constant factor.

The data may be entered in a tabular form,(see Table 15.1). The percentages in the column may be calculated with respect to the total dust.

Precautions

(i) For Sampling Site Selection

The following criteria may be observed in the selection of sampling site for dust-fall measurement:

1. It shall have a free exposure so that the sample is collected by gravity settling only.

2. It shall not have any interference from the buildings or any other higher objects.

3. It shall have easy accessibility but shall have security so as to avoid any tampering.

4. The dust-fall collectors shall be placed at a height of 3 to 15 metres above the ground level.

5. No stack or chimney should be present in the vicinity of the site.

6. Whenever higher buildings in the immediate vicinity cannot be avoided, the top of the building shall be more than 30° above the sampling point, i.e. a line drawn from the sampling jar to the nearest edge of the highest point on any building shall form not more than a 30° angle with the horizontal.

(ii) For number of Sampling Stations

There are no guidelines available. The investigator has to use his own discretion. In air quality survey network programme, samples are to be collected from various parts of the city representing residential, commercial and industrial zones. Hence, at least one sampling station is to be fixed in each zone.

(iii) For Sampling Period

Sampling period shall be one calendar month. There is no harm if the sample is taken after 28 or 32 days due to practical constraint. The results are then corrected to 30 days.

15.3 DETERMINATION OF RAINFALL

Rainfall is measured by raingauge. The total amount of rainfall which reaches the ground in a particular period is expressed as the depth to which it would cover a horizontal projection of the earth's surface. In this process, there should be no loss by evaporation and if the rainfall is in the form of snow, then it should be melted.

15.3.1 Apparatus

The most widely used raingauge in our country is shown in Fig. 15. 2. It consists of a collector and base. Both are made of fibre glass reinforced polyester. It has a slight taper with the narrower portion at the top, as shown in the figure. The bottle used has

capacity of 4 litres can be increased either by decreasing collector size or taking bigger bottles. For example, a 200 sq cm collector with a 2 litre bottle can measure 100 mm rainfall. A 100 sq cm collector with a 2 litre bottle can measure 200 mm rainfall. Similarly, a 200 sq cm collector with 4 litre bottle can measure 200 mm rainfall.

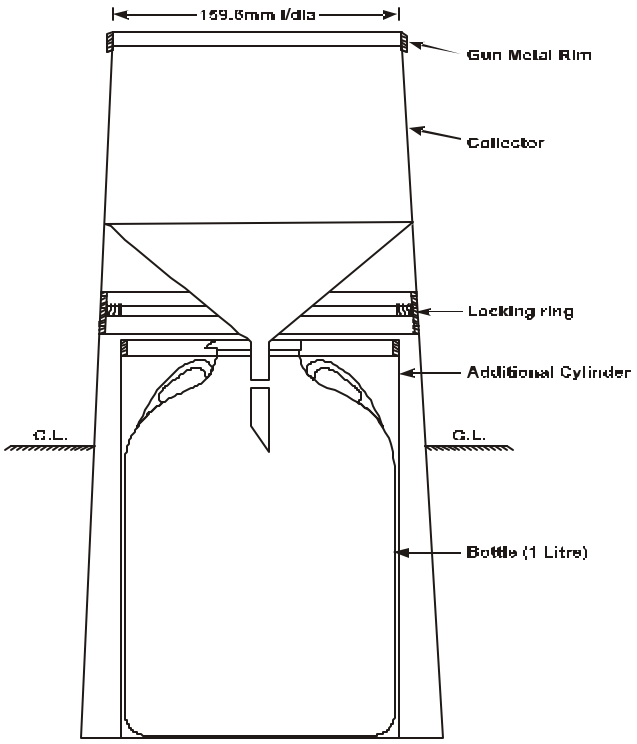

Fig. 15.2: Raingauge

15.3.2 Installation

The raingauge should be installed on a fixed concrete foundation, 60×60×60 cm, sunk into the ground as shown in Fig. 15.3. The standard height from the ground level is

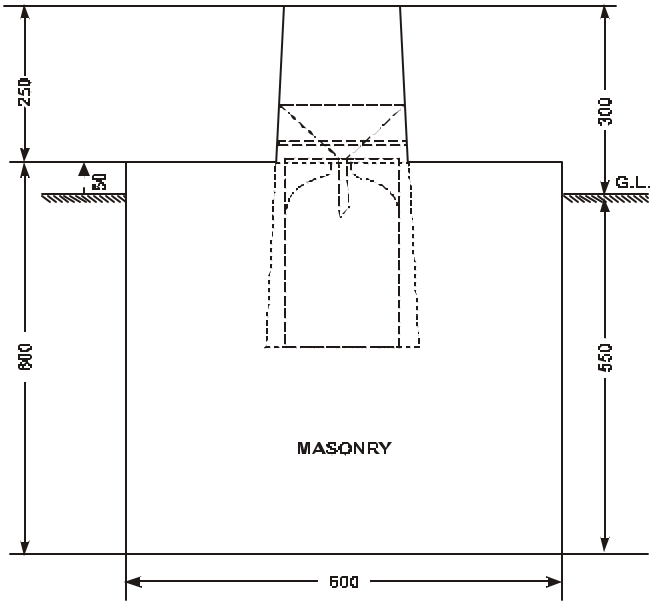

Fig.15.3: Installation of Raingauge

kept constant, i.e. 30 cm. The foundation should be made on a levelled ground of large area. Raingauge should not be placed on a roof or a wall. The place should be protected by direct wind if any, which may disturb the normal rainfall. If the place is surrounded by a belt of trees at a distance from the gauge, it will be better.

15.3.3 Measurement

The amount of rainfall collected is measured by a graduated measuring glass commonly known as rainmeasure. Separate rainmeasures are available for the 100 and 200 sq.cm collectors. To measure, the water from the bottle and from the additional cylinder (if any) is poured carefully into the rainmeasure. The rainmeasure should be placed on a table and viewed at the level of the water. Smallest part of the rainmeasure stands for a rainfall of 0.2 mm. The reading should always be estimated to the nearest of 0.1 mm. If there is more water in the bottle, then a number of measurements should be taken and the sum total of all the readings is calculated. If there is snowfall or hail or the water is frozen, then a measured amount of warm water is added to melt the snow completely and the same amount is subtracted after measurement. If the snow is found above the collector, then that also is melted and measured.

15.3.4 Precautions

The following precautions must be observed to get good results.

1. The bottle, additional cylinder and collector must be cleaned regularly to remove dust and dirt. This keeps the collector choke free. These are also examined for leaks regularly.
2. Outer surface of the collector must be painted regularly.
3. Care should be taken not to dent or deform the gunmetal rim of the collector by rough handling.

Special attention is given to the following points:

4. The water collected should not be evaporated. So, the material used should have low thermal conductivity. Fibre glass reinforced polyester is commonly used.
5. Deep set funnel should be provided so that loss of catch due to splashout of the water droplets is reduced.

15.4 DETERMINATION OF HUMIDITY

Humidity is a measure of the water vapour content of the atmosphere.

The relative humidity (RH) of air can be measured by (i) Hair Hygrograph and (ii) dry and wet bulb thermometres. The dry bulb and wet bulb thermometres are basically an ordinary glass thermometres. The dry bulb thermometre gives the actual air temperature while the wet bulb thermometre is covered by wet muslin wick and brisk air is blown across the wick (3 m s^{-1}). As a result of evaporative cooling, the wet bulb temperature becomes lower than the dry bulb temperature.

15.4.1 By Hair Hygrograph Method

The relative humidity (RH) of air can be measured by Hair Hygrograph. The length of a human hair (fat free) varies considerably with relative humidity than other meteorological elements. The length increases as the relative humidity increases and vice-versa. The change in length is not directly proportional to the change in relative humidity. For example, a change of 10% RH (from 80% to 90% RH) causes a much smaller change in length of the hair than an equal change (say from 30% to 40% RH). However, between 20 and 100% relative humidity, the change in length of the hair is proportional to the logarithm of the change in relative humidity. Depending on this principle, a pen is designed whose movement is proportional to the relative humidity.

(a) Apparatus

Hair hygrograph consists of a standard drum which makes a complete revolution in 25 ½ hours. The chart used has a range 0 to 100% RH. The smallest division being equal to 2% i.e. the RH can be read to nearest 1%. The simplified diagram of a hair hygrograph is shown in the Fig. 15.4. The hair movement plate is covered with a perforated

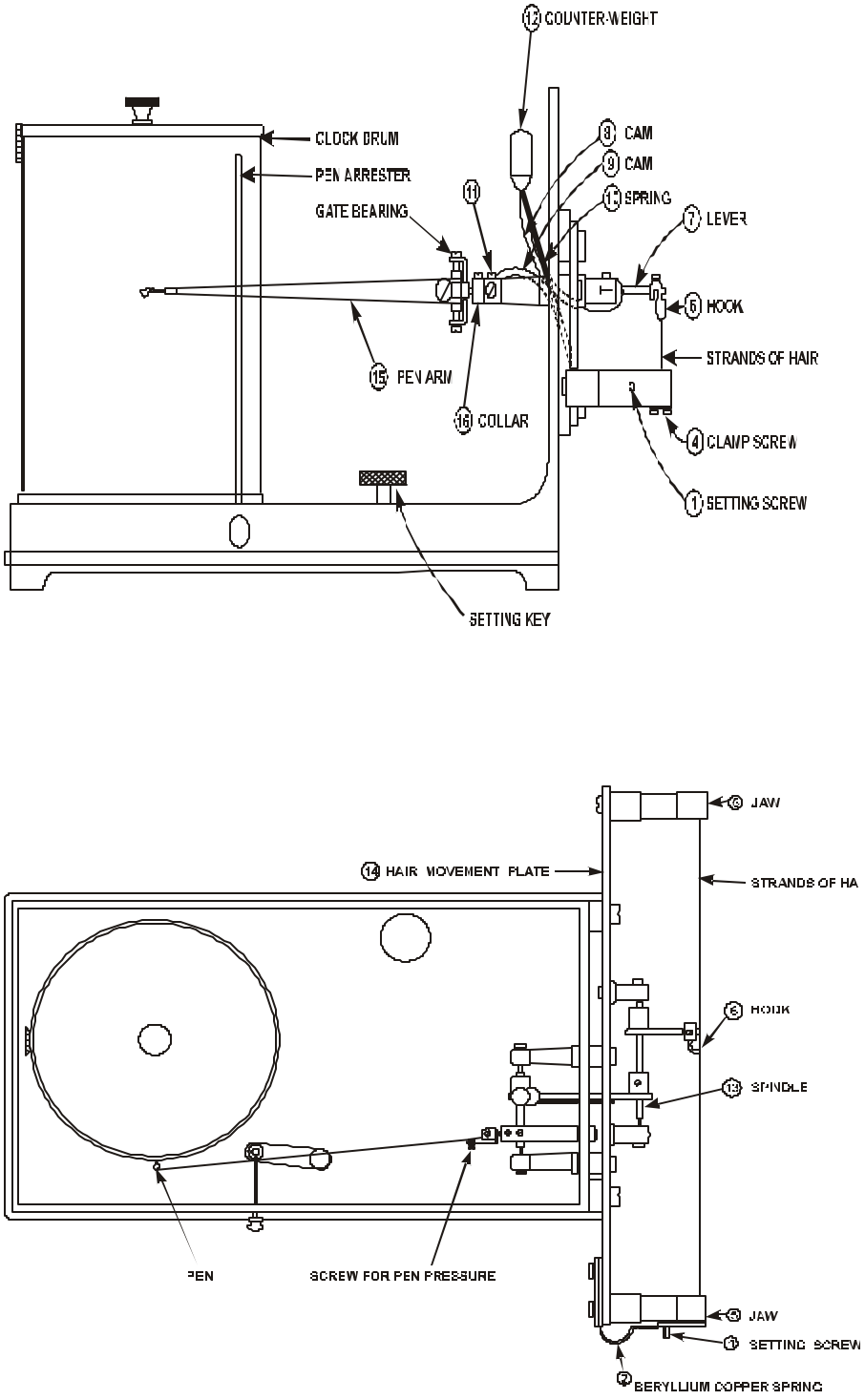

Fig. 15.4: Hair Hygrograph

brass guard and the drum is covered with a metallic cover having glass window. The length of the hair changed results in the displacement of the hook either upwards or downwards. This displacement is magnified by the lever and pen arm. This magnification is so modified that the displacement of the pen on the chart is directly proportional to the change in relative humidity.

(b) Installation

This instrument is placed in a large Stevenson Screen. The screen should be located in a place where the surrounding air is not polluted by excessive smoke or dust particles. Oil vapour and ammonia exposure should be avoided because these are extremely harmful to hair.

(c) Analysis

Comparison between the readings of the hygrograph and psychrometre (a dry and wet bulb thermoter combination) is done as the difference in the lags of the two instruments can cause a difference of as much as 5%. So 100% humidity check should be carried out periodically (once in a week) and the pen adjusted to read 95% when the hair is in equilibrium. For lower humidity check, the adjustment is made in a room when temperature is fairly constant. The psychrometre check should be done at normal wind speed at Stevenson Screen. The readings of wet and dry bulb thermometres are noted and RH is calculated from the table. This value is compared with the hygropraph reading at the same time. Then the pen point is adjusted by the screw and run for half an hour and again compared. If the hygrograph reading is 10% more than psychrometre readings, then the tension of the hair strand should be adjusted.

(d) Maintenance

The hair should be kept clean by washing it with distilled water once in a week. Errors due to dust sometimes are as much as 15%. The hair lasts for several years with proper maintenance. A complete recalibration of the instrument is necessary when the hair is replaced.

(e) Precautions

1. The hair should be kept clean by washing it with distilled water once in a week.

2. Errors due to dust sometimes are as much as 15%. The hair lasts for several years with proper maintenance. A complete recalibration of the instrument is necessary when the hair is replaced. Calibration of hair hygrograph is done by dry and wet bulb method.

15.4.2 By Dry and Wet Bulb Method

(a) Procedure

(i) As discussed above, relative humidity can be determined by wet bulb and dry bulb temperatures. Record the temperature by a dry bulb thermometre. Put a cotton-wick on lower part of the thermometre. Wet the cotton and use a fan to pass air over the thermometre. As the water evaporates, the temperature decreases. After the temperature has stopped decreasing, record it as the “wet bulb” temperature.

Determine relative humidity from the recorded temperatures (using Relative Humidity Table 15.2 given below:)

Table 15.2 : Relative Humidity Table

T_{db} (°C)	Dry Bulb - Wet Bulb Temperatures (°C)														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**14**	**16**	**18**	**20**
2	84	68	52	37	22	8									
4	85	70	56	42	29	26	3								
6	86	73	60	47	34	22	11								
8	87	75	63	51	39	28	18	7							
10	88	76	65	54	44	33	23	14	4						
12	89	78	67	57	47	38	29	20	11	3					
14	89	79	69	60	51	42	33	25	17	9					
15	90	80	71	62	54	45	37	29	22	14					
18	91	81	73	64	56	48	41	33	26	19	6				
20	91	82	74	66	58	51	44	37	30	24	11				
22	91	83	75	68	60	53	46	40	34	27	16	5			
24	92	84	76	69	62	55	49	43	37	31	20	9			
26	92	85	77	70	64	57	51	45	39	34	23	14	4		
28	92	85	78	72	65	59	53	47	42	37	26	17	8		
30	93	86	79	73	67	61	55	49	44	39	29	20	12	4	
32	93	86	80	74	68	62	56	51	46	41	32	23	15	8	1
34	93	87	81	75	69	63	58	53	48	43	34	26	18	11	5
36	93	87	81	75	70	64	59	54	50	45	36	28	21	14	8
38	94	88	82	76	71	65	60	56	51	47	38	31	23	17	11
40	94	88	82	77	72	66	62	57	52	48	40	33	26	19	13
42	94	88	83	77	72	67	63	58	54	50	42	34	28	21	16
44	94	89	82	78	73	68	64	59	55	51	43	36	29	23	18

15.4.3 Precautions

1. Use of distilled water will reduce the salt deposits, which build up on the exposed wick and would extend the life of the wick.
2. It is essential that dirty wick is replaced with a new wick.
3. A small amount of disinfectant may be added to the water to reduce the chance of bacterial contamination.

Result

1. RH by hair hygrometre =……on……..hr.
2. RH by dry and wet bulb method= ……on ……...….hr.