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Short Communication

Comparison of inherent properties of glass fibre filters

SARIKA A. VARADE, APARNA GAJBHIYE, K. M. PHADKE AND ANIMESH KUMAR*
National Environmental Engineering Research Institute (NEERI), Nehru Marg, Nagpur 440 020, India.
email: apcneeri_ngp@sancharnet.in; Phone: +91-0712-2249885-89 Extn. 271; Fax: +91-0712-2249895.

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Abstract

In Indian urban atmosphere, toxic elements are found in micro and sub-micro levels. Glass microfibre filters are used for collection of air samples for determination of trace quantities of these toxic metals in the air and it is preferable to choose filter containing low blank concentration. The concentration of Pb, Cr, Ni and Cd in the filters manufactured by three manufacturers, viz. Gelman, Whatman and Nupore is studied in this paper. Though comparable, the least concentrations were observed in the filter manufactured by M/s Nupore Filtration Systems, India. The concentration of Fe and Zn however is very high in the range of 70–251 and 1816–6604 *m*g/g, respectively, in all the filters.

Keywords: Glass fiber filter, trace metals, air pollution.

1. Introduction

The primary purpose of this study is to study the suitability of glass micro fiber filter commonly used in the determination and characterization of airborne particulate matter (PM) in India. The study was performed on three commercially available filters in the country. Glass microfibre filters are widely used for both routine monitoring of air pollution and specialized monitoring of solid pollutants, microorganisms, oil and acid smokes in air, especially due to their low resistance to air flow, higher particle loading capacity, and excellent optical characteristics. These filters consist of a tightly woven fibrous mat and are generally manufactured from borosilicate glass.

Such filters are used in different sampling systems for chemical characterization using different analytical techniques. Each of the particulate analytical techniques places different demands on the filter. Sometimes these demands are contradictory and a single filter sample cannot be used for all the desired analyses. General criteria considered while selecting filter media are: (i) mechanical stability, (ii) temperature stability, (iii) chemical stability, (iv) particle collection efficiency, (v) flow resistance and loading capacity, and (vi) concentration of analyte in blank filters.

These filters require treatment and representative chemical analyses before use. Excessive blank levels and filter matrix interferences discovered during or after the completion of

*Author for correspondence.

air-quality studies have compromised their results. It is therefore desired that at least one filter from each lot (typically 100 filters) received from a manufacturer is analyzed for all parameters and analyte species to verify that the blank levels are within the acceptable range. Such results are used as laboratory blank for that lot. A lot is rejected if the filters do not pass this acceptance test. Each filter is individually examined over a light table prior to use for discoloration, pinholes, creases, or other defects. In addition to laboratory blanks, 5–10 filters are designated as field blanks to follow all handling procedures except for actual sampling. The air flow rate through glass fiber filter decreases with the mass deposition on it due to lodging of particulate into the glass fiber matrix of the filter. Efforts were therefore made to compare drop in flow rate with the PM mass deposition on the filters.

In this study, glass fiber filters of three different makes and models, viz. Whatman GF/A, Gelman A/E and Nupore GF1 have been compared for drop in flow rate with mass deposition, content of toxic trace elements and collection of PM10 in ambient air.

2. Materials and methods

Initial weight of 100 filter papers from one batch of each supplier was taken on an electronic balance (model AD-300S). Their average mass and standard deviation were calculated to compare filter density. RSPM samplers (model APM 460NL) were installed at National Ambient Air Quality Monitoring site at the National Environmental Engineering Research Institute (NEERI), Nagpur, to collect daily/24-hour samples of airborne respirable particulates. Samplers were collocated at minimum 3 m apart to avoid sampling field influence. Three different commercially available $8" \times 10"$ size filters were installed daily in each of the three samplers. Different make filters were rotated through different samplers on a daily basis to avoid possible specific sampler bias. Sampling flow rate was noted during the sampling period at hourly intervals for each filter paper. Graphs were drawn between decrease in flow rate and particulate mass deposition on the filter. PM10 mass collection on different filters was also compared by operating the samplers simultaneously.

Three filters each were subjected to chemical analysis to determine the contents of toxic trace elements. For this purpose, 12 circles of 2.8-cm dia each were punched out from filter paper and digested in concentrated nitric acid (Excelar grade) by using microwave digestion system (model ETHOS 900). The digested sample was filtered through Whatman paper no. 42 and final volume of filtrate was made up to 100 ml with double distilled water. The solution was analyzed to determine Cd, Cr, Ni and Pb by ICP-AES [1].

3. Results and discussion

Filter make and description, as supplied by manufacturers [2–4], are listed in Table I. Initial mass of the filter and flow rate are important parameters for gravimetric determination of airborne particulate matter concentration. However, for chemical characterization of particulate matter samples, the important properties of the filter paper required are blank concentration, initial mass and flow rate [5]. Hence, an attempt is made to compare the glass microfiber filters from the three manufacturers with respect to these parameters. The average filter weight of 100 filters each along with standard deviation and initial flow rate are presented in Table II. Though the average weight and initial flow rate of all the three

Table I
Filter data supplied by manufacturers

Sl. no.	Properties	Whatman GF/A	Pall Gelman A/E	Nupore GF1	Whatman EPM2000
1.	Filter media glass	Borosilicate glass	Borosilicate glass	Borosilicate glass	
2.	Binder	No binder	No binder	No binder	
3	Particle retention size liquid (micron)	1.6	1 (nominal)	1.6	0.3
4.	Initial filtration speed				
	Herzberg	62		62	NA
	ASTM	13		13	NA
5.	Thickness (mm)	0.26	0.457	0.26	0.43–0.45
6.	Weight (g/m^2)	53		53	80
7.	Loading capacity	High		High	NA
8.	Wet burst, kPa/psi	2.0/0.29		2.0/0.29	NA
9.	Dry burst, kPa			13.8 KN/m^2	NA
10.	DOP penetration @ 32 lpm/100 cm^2			0.01	
11.	Tensile strength, KGF			0.50	
12.	Equivalent grades			GF/A	
13.	Dry tensile (g/cm)				700/1.5
14.	Typical air flow rate (lpm/cm^2) at 10 psi		45		1.52 m^3/min
15.	Brittleness				No crack larger than 1"
16.	Integrity				2.5 mg
17	Weight loss				0.75%
18.	Lead content				0.25 *m*g/filter
19.	Alkalinity				25 *m*eq/g of filter

makes are comparable, the weight of the filter supplied by M/s Nupore Filtration Systems is the highest.

A comparison of 24-h average PM10 concentrations during six days of experiment and determined using different make filters is presented in Table III. The results obtained using different filters for a day are comparable. The small variations observed in PM concentration may be attributed to dynamic state of ambient air, conversion of gaseous pollutants to

Table II
Average weight and standard deviation of three filter papers used in air-quality monitoring

Filter type and make	Batch no.	Initial weight of filter paper (g)		Initial flow rate (m^3/min)
		Average	Standard deviation	
Nupore GF1	HVS 1430102	2.811	0.023	1.1
Whatman GF/A	A 548811	2.728	0.011	1.25
Gelman A/E	2001 AP22	2.726	0.046	1.21

Table III
Concentration of PM10

Day	PM10 concentration (*m*g/m^3)		
	Whatman make	Gelman make	Nupore make
1	149	158	162
2	63	64	59
3	90	80	86
4	86	75	69
5	139	130	134
6	56	60	54

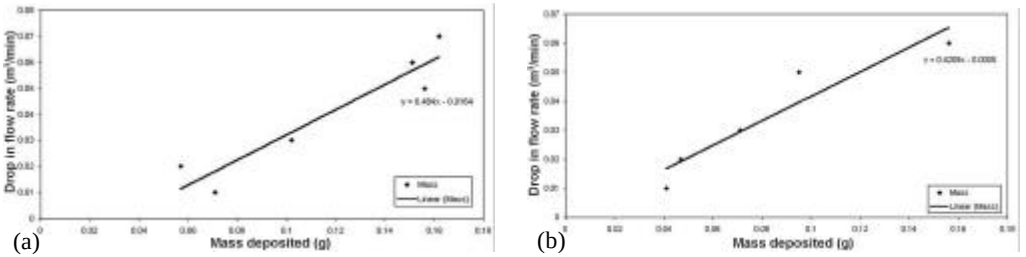

FIG. 1. Change in flow rate with mass deposition: (a) Nupore and (b) Gelman filter papers.

solid particulates, viz. sulphates, nitrates, etc. on the surface of filters. Witz *et al.* [6, 7] compared different types of Gelman-make glass filters (A, AE, Spectro Grade and a special batch of Type A supplied by EPA) for determining the concentration of total suspended particulate matter (TSP) and their chemical composition and reported that the difference in TSP and lead loading were as high as 20 and 171, respectively, using Gelman A as a reference. They further reported that catalytic conversion of SO_2 and NO_2 to particulate sulfates and nitrates, respectively, on contact with filter surface, though pH-dependent, are responsible for the observed high values [6, 7]. Conversion of SO_2 and NO_2 is also facilitated by increased humidity, temperature, NH_3 and the presence of trace metals or metal oxides (e.g. PbO, Fe_2O_3, CaO and Al_2O_3) on the filter surface [8]. However, such large variations were not observed in this study due to the presence of insignificant levels of SO_2 (6–8 $\mu g/m^3$) and NO_2 (7–23 $\mu g/m^3$) at the study site [9].

The decrease in air flow rate through glass fiber filter with the mass deposition on it was studied (Fig. 1). The graphs show comparable results (0.4 m^3/min/g of PM deposition) of the filters of two different makes.

Determination of micro and sub-micro level concentration of toxic metals in ambient air is of great concern due to their human health implications. Accurate determination of such low concentration requires the filter blank values to be low. The average concentrations of elements in each filter type were, therefore, determined (Table IV). The results show that compared to Gelman and Whatman, the Nupore-make filter contains lesser concentrations of Cr, Pb, Cd and Ni. The results are comparable to those reported by Schroeder *et al*. [10]. The levels of Fe and Zn ranged 70–250 and 1800–6000 $\mu g/g$, respectively. High levels of these elements in glass fiber filter, 752 and 30105 $\mu g/g$, respectively, were also reported by Schroeder *et al.* [10].

Filter papers of all the three makes studied in this paper are therefore found suitable for ambient air-quality monitoring and determination of toxic trace metals in atmospheric particulates.

Table IV
Elemental concentration in the filters (concentrations in ($\mu g/g$))

Filter type	Cr	Pb	Cd	Ni
Nupore GF1	16.81	94.78	7.13	11.97
Whatman GF/A	21.76	129.02	8.70	16.89
Gelman A/E	20.01	113.14	8.46	17.70
EPM 2000	16.41	19.33	93.18	37.40

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