

Int. J. Biometeor. 1963, vol. 7, issue 1, pp. 27-34

Effect of Meteorological Events on Ragweed Pollen Count

by

R. M. Holmes* and I. J. Bassett

INTRODUCTION

There is considerable concern among health officials in recent years over the increased incidence of ragweed induced hay fever (Dingle, 1957a, 1957b; Goodwin et al, 1957). Dingle (1955) has described ragweed pollinosis as being a botanical-meteorological-medical problem, i.e., the ragweed plant produces pollen which is carried by air currents to sensitive persons. The influence of meteorological factors on hay fever pollen counts has been demonstrated recently by Dingle (1957b), Bianchi et al. (1959), Jones (1952), Smith and Brooks (1954), Gilbert (1950), and others. In general, it has been shown that ragweed pollen counts rise sharply in early morning hours with a simultaneous decrease in relative humidity. Pollen counts generally decrease rapidly in the afternoon and remain low through the night. The present work was undertaken to relate daily and hourly ragweed pollen counts to specific meteorological events.

MATERIALS AND METHODS

The experiments were conducted at the Central Experimental Farm, Ottawa, which is an area of approximately 1250 cultivated acres near the centre of Ottawa. The experimental area was open cultivated ground with a large wind fetch in all directions. Common or short ragweed, *A. ARTEMISIIFOLIA*, was abundant in cultivated fields, waste places and along roadsides within the immediate area. Surveys conducted throughout the city of Ottawa in recent years have shown that Giant ragweed, *A. TRIFIDA*, occurs frequently in waste places and low wet areas throughout the city while the perennial ragweed, *A. CORONOPHOLIA*, has not been found within the city limits. The ragweed hay fever season at Ottawa usually begins about 15 August, reaches a peak about 28 August, and then ends shortly after 15 September.

Volumetric counts of air-borne ragweed pollen were taken during the 30-day season in 1961 using a sampler that has been described previously by Voisey and Bassett (1961). This apparatus draws a metered volume of air over a glass slide coated with glycerine jelly. The slides were individually exposed to the air stream and changed automatically each hour. The magazine of the sampler holds 24 slides in an exchangeable drum. The sampler was mounted one meter above the grass surface in the weather site, and all observations were taken in this area. Relative humidity and air temperature measurements were made with a hair hygograph and bimetal thermograph, respectively. Lapse rates were recorded from ventilated and shielded temperature sensors supported at 20, and 190 ft on a 200 ft tower. Slides were also exposed in an apparatus of the Durham gravity-type, at ground level and on the tower at 20, 90 and 190 ft levels. The slides were changed daily at 4:00 p.m.

*) Agro-Meteorological and Taxonomy Sections, Plant Research Institute, Research Branch, Canada Department of Agriculture, Ottawa.
Received 9 May 1963.

RESULTS AND DISCUSSION

In the following paragraphs pollen counts will be discussed in relation to each meteorological event. Pertinent items in the literature will also be introduced in this context. The events of three different types of days are shown in Figs. 1-3 together with the pollen counts.

A "typical ragweed hay fever day" has a sharply rising pollen count during early to mid-morning and a rapidly decreasing count in the afternoon. Evening and night counts are usually very low. In the sample shown in Fig. 1, an inversion occurred from 3:00 to 6:00 a.m. with heavy ground fog, 100% relative humidity and cool temperatures. Following sunrise, the fog burned off, the relative humidity decreased rapidly, the temperature rose, an early super-adiabatic lapse developed and the pollen count increased sharply reaching a peak between 9:00 and 10:00 a.m. These observations are similar to those of Dingle (1957a,b) and others (Jones, 1952; Voisev and Basset, 1961).

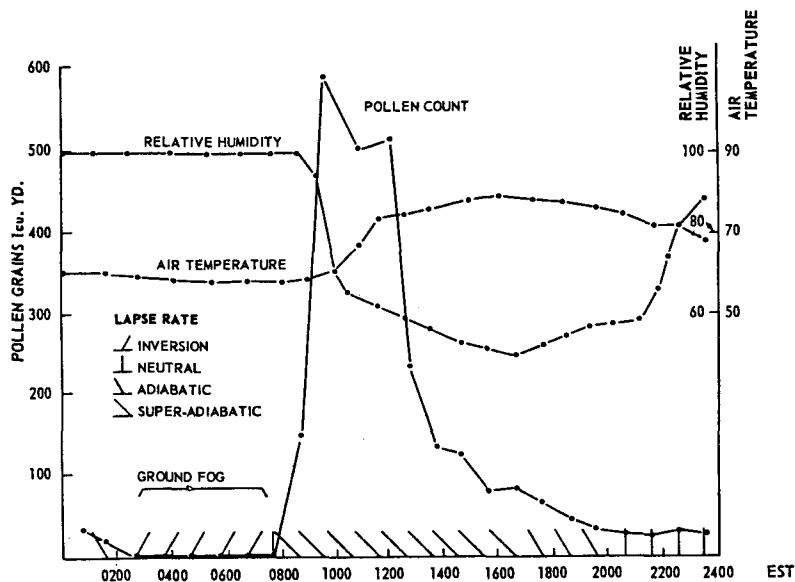


Fig. 1: Hourly variation in ragweed pollen count and meteorological factors, 24 August 1961.

Bianchi, Schwemmin and Wagner (1959) have described three major steps that occur on "typical days" before actual dispersion or flotation of pollen takes place, viz. (a) the ejection of pollen in clumps from the flower; (b) a period of adherence of the pollen clusters to adjacent vegetation; (c) the flotation of the pollen by turbulent air. It is reported that low humidities are necessary before the first step in the process can occur. Generally, our observations tend to support this view, but since our measurements were of pollen flotation (step (c)) the onset of atmospheric turbulence was more closely related to periods of peak pollen count. In fact, on no occasion did peak pollen counts occur without super-adiabatic (turbulent) conditions. In many instances relative humidity sharply decreased during these periods. These trends are shown in Table 1. Also listed in Table 1 are the times of peak pollen count and a statement of the general weather condition. Note that the period of maximum pollen concentration varies widely, but occurs during the morning hours (except on mornings with rain).

Table 1. Meteorological condition during period of peak pollen counts

Day	Time of peak pollen count	Condition during period of rising pollen count		Evening rise in pollen count	General weather (3)
		Decreasing (1) rel. humidity	Super-adiabatic lapse (2)		
Aug. 16	8-9 a.m.	N	Y	N	Partly cloudy, moderate winds N.W.
Aug. 17	11-12 a.m.	Y	Y	N	Partly cloudy, cool, light winds N.W.
Aug. 18	11-12 a.m.	Y	Y	N	Clear and cool, light winds N.W.
Aug. 19	9-10 a.m.	N	Y	Y	Clear and warm, light winds S.W.
Aug. 20	6-7 a.m.	N	Y	N	Clear and warm, moderate winds S.W. to W.
Aug. 21	8-9 a.m.	N	Y	Y	Cloudy to partly cloudy, cool, winds N.E.
Aug. 22	-	-	missing data	-	-
Aug. 23	12-1 p.m.	Y	Y	Y	Morning showers, clearing, light winds S. to S.W.
Aug. 24	9-10 a.m.	Y	Y	Y	Morning fog, clearing, light winds E.
Aug. 25	9-10 a.m.	Y	Y	Y	Noon shower, clearing, light winds S.E.
Aug. 26	10-11 a.m.	Y	Y	Y	Noon trace of rain, warm, light winds S.E.
Aug. 27	9-10 a.m.	N	Y	N	Noon rain, moderate winds S.W.
Aug. 28	8-9 a.m.	Y	Y	Y	Early morning rain, moderate winds S.W.
Aug. 29	1-2 p.m.	Y	Y	N	Morning rain, moderate, light winds W. to N.W.
Aug. 30	7-8 a.m.	Y	Y	Y	Early fog, clearing, warm, light winds N.W.
Aug. 31	9-10 a.m.	N	Y	Y	Clear, moderate, winds moderate N.W. to W.
Sept. 1	1-2 p.m.	Y	Y	Y	Morning cloudiness, clearing, light winds S.W.
Sept. 2	9-10 a.m.	N	Y	Y	Morning rain, partly cloudy, light winds S.E.
Sept. 3	9-10 a.m.	Y	Y	N	Cloudy, warm, moderate winds S.W.
Sept. 4	10-11 a.m.	Y	Y	N	Clear, warm, moderate winds S.W.
Sept. 5	10-11 a.m.	Y	Y	N	Clear, warm, moderate winds N.W.
Sept. 6	12-1 p.m.	Y	Y	N	Clear, cool, moderate winds N.E.
Sept. 7	10-11 a.m.	Y	Y	N	Clear, warmer, moderate winds N.W.
Sept. 8	9-10 a.m.	Y	Y	Y	Clear, warmer, light winds N.
Sept. 9	9-10 a.m.	Y	Y	Y	Clear, warmer, moderate winds S.W.
Sept. 10	6-7 a.m.	N	Y	Y	Clear, warmer, moderate winds S.W.
Sept. 11	8-9 a.m.	Y	Y	Y	Clear, warmer, morning trace of rain, light winds N.W.
Sept. 12	9-10 a.m.	N	Y	N	Cloudy, cool, moderate winds N.E.
Sept. 13	6-7 a.m.	N	Y	N	Cloudy, cool, morning rain, winds N.E.
Sept. 14	1-2 p.m.	N	Y	N	Cloudy, fog, morning rain, winds S.E. to S.W.
Sept. 15	8-9 a.m.	N	Y	N	

(1) Y = Yes; N = No.

(2) Lapse rate was measured between 20 and 200 ft at the weather site.

(3) General weather during day and winds during 6-8 hours previous to the period of peak pollen count.

During the morning hours on 25 August, a convection storm caused 0.10 in of precipitation which washed the atmosphere free of pollen (Fig. 2). The pollen was remitted by noon and reached a peak count between 1:00 and 2:00 p.m. This period was also characterized by a super-adiabatic lapse and decreasing humidity. Gustiness during early morning may have refloated some pollen which settled overnight and caused the small rise in pollen count between 4:00 and 5:00 a.m.

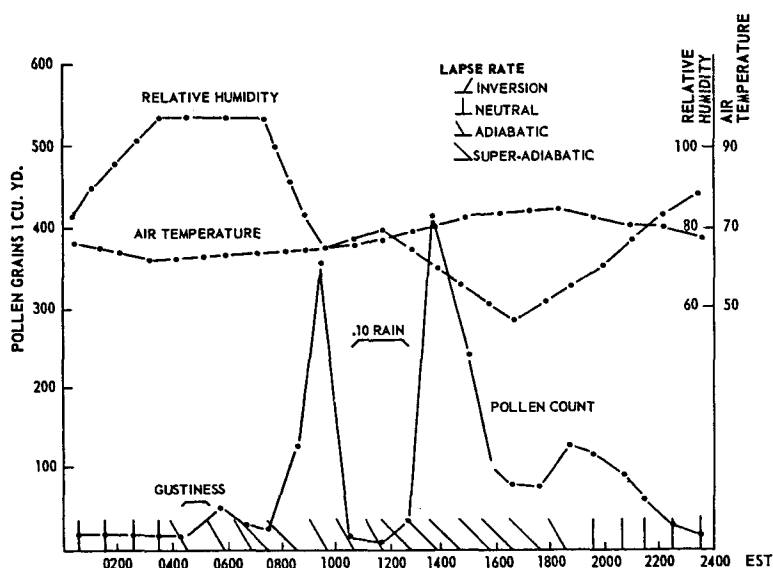


Fig. 2: Hourly variation in ragweed pollen count and meteorological factors, 25 August 1961.

August 31 was atypical in several respects. Pollen counts began to rise between 3:00 and 4:00 a.m. under slightly lapse to adiabatic conditions with very little change in relative humidity or temperature. Super-adiabatic lapse rate developed between 6:00 and 7:00 a.m. with a sudden rise in pollen count. Reflotation was probably the cause of the very early rise in pollen count. The wind started at about 3:00 a.m. and speeds were constant at 3-5 mph with no dew. There was a heavy pollen yield the previous day so the vegetation was probably well covered with settled pollen.

A further interesting feature of 31 August was the sudden rise in pollen count in the evening. This period was characterized by a neutral lapse, and decreasing temperatures. However, the relative humidity decreased from 90 to 80% and the wind speed increased from calm to 3-4 mph and this may have caused some refloitation. The evening rise in pollen count was also noted on several other occasions (Table 1), not all of which were accompanied by increased wind speeds or decreasing humidity. Nearly all of these situations were during periods of neutral to slightly lapse conditions. Hewson (1960) suggests that in the case of evening industrial pollution, a nocturnal inversion forms over the cooling rural countryside. When this air passes over the warmer urban centres, the inversion is destroyed and the pollutants are carried to the surface. A similar condition may be occurring in the cases of an evening rise in pollen counts.

It is interesting to note, that on 19, 20, 21 August the relative humidity decreased in the early morning during slightly lapse conditions 2-3 hours in advance of the development of a super-adiabatic lapse. The pollen was probably ejected on to ad-

jacent vegetation during this period but flotation did not occur until super-adiabatic conditions developed.

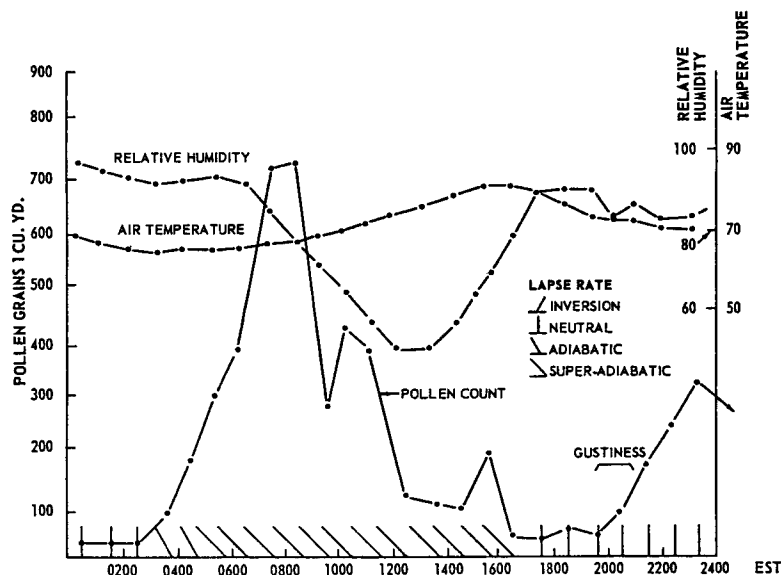


Fig. 3: Hourly variation in ragweed pollen count and meteorological factors, 31 August 1961.

DAILY VARIATIONS IN POLLEN COUNT

An index of daily pollen yield at the weather site was obtained by determining the area under the hourly curves. These data showed a double peak, the first of which occurred on 21 August, and the second on 31 August (Fig. 4). The first peak was apparently the result of the natural maximum flowering of the common or short ragweed growing nearby and the second was probably due to the regrowth of the same plant to the flowering stage after being harvested with grain and other crops at the Experimental Farm.

Pollen counts from a Durham gravity slide sampler are not shown. Occasionally the gravity slide measurements followed the volumetric determinations qualitatively, but there were numerous exceptions. It was not possible to obtain a constant factor that could be used to convert gravity to volumetric measurements. Durham samplers were also arranged on the weather site tower at ground level, 20, 90 and 190 ft and slides were changed daily at 4:00 p.m. The data are not shown because they were inconclusive and inconsistent. The inadequacies of the gravity slide method are fairly well known and are fully described elsewhere (Dingle, 1957b; Harrington et al., 1959; Ogden and Raynor, 1960).

An analysis of wind data failed to show any conclusive relationships with daily yield index. There was a trend, however, toward higher counts during periods of south-westerly winds. This is not surprising since most of the ragweed in Ontario grows to the south-west of Ottawa. The counts in Ottawa are dominated by very local ragweed populations and microclimate.

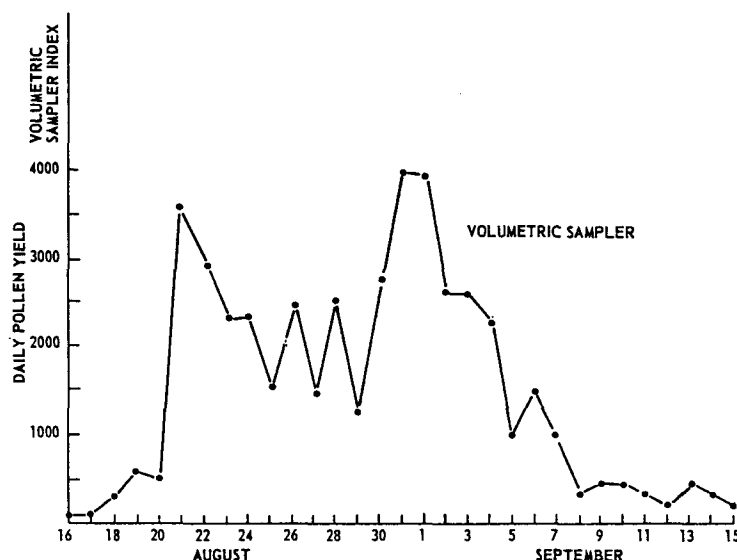


Fig. 4: Daily pollen yield during ragweed season of 1961 as determined by a volumetric sampler.

It has been shown (Bianchi et al., 1959) that the rate at which a ragweed flower is brought to the stage of dehiscence is a function of temperature. Then, after the flower has been thusly "prepared", the matter of dehiscence is a function of atmospheric vapor pressure. The flowers will not disgorge pollen until the vapor pressure reaches threshold which permits the anther envelope to dessicate to the point where it ruptures and allows the pollen to be spilled out. The daily yield of pollen then, is a function of the number of flowers brought to the state of dehiscence and then dehiscid, or in other words, a function of temperature and vapor pressure.

A simple correlation between daily pollen yield and temperature during the 4-hour period prior to peak pollen count was calculated and found to be significant at the 0.05 level ($r^2 = .29$). It was assumed that the flowers were dehiscing during the period four hours previous to peak pollen counts although no observations were taken to verify this. Similarly, a correlation between daily pollen yield and atmospheric vapor pressure, relative humidity and vapor pressure deficit during the 4-hour period prior to peak pollen count was calculated and found to be non-significant. The product of the temperature and atmospheric vapor pressure was found to be only weakly correlated with the daily peak pollen count.

More elaborate mathematical models are possible in a case like this, that would accurately describe the phenomena. The lack of better relationships in our situation is probably mainly due to:

- (a) errors in choice of period of anther sac extension and rupture;
- (b) errors in assuming that screen temperatures and vapor pressures are the same as in the plant environment;
- (c) errors in the assumption that our yield index (e.g. flotation) under field conditions is directly related to the number of dehiscid anther sacs.

SUMMARY

An attempt has been made to relate peak ragweed pollen counts to specific meteorological events. From volumetric counts taken hourly during the entire 1961 ragweed season at Ottawa, it was found that periods of maximum air-borne pollen concentration were directly related to periods of maximum air turbulence e.g. development of super-adiabatic lapse. In many cases, a sharp decrease in relative humidity decreased several hours in advance of the development of a super-adiabatic lapse with no increase in pollen count. A nocturnal rise in pollen count was often noted in calm, moderately humid air with neutral to slightly lapse rates. This may be the result of reformation or of the break up of a nocturnal inversion which carries pollen laden air to the surface. Highest daily yields tended to occur during south-westerly air flows. There was also a trend for daily yields to be positively related to temperature during early morning hours.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance of the following colleagues: Dr. Katz and Staff of Department of National Health and Welfare for tower and lapse rate data, and Mr. C.W. Crompton for preparing sampler slides for pollen count, and D. Russello for the daily changing of microscopic slides, and taking temperatures and humidity observations.

Contribution No. 298 from the Plant Research Institute, Research Branch, Canada Department of Agriculture, Ottawa.

REFERENCES

- BIANCHI, D.E., SCHWEMMIN, and WAGNER, W.H. Jr. (1959): Pollen release in common ragweed (*AMBROSIA ARTEMISIIFOLIA*). Bot. Gz., 120 : 235-243.
- DINGLE, A.N. (1955) : A meteorological approach to the hay fever problem. J. Allergy, 26 : 297-304.
- DINGLE, A.N. (1957a) : Meteorological considerations in ragweed hay fever research. Fed. Proc., 16 : 615-627.
- DINGLE, A.N. (1957b) : Hay fever pollen counts and some weather effects. Bull. Am. Met. Soc., 38 : 465-469.
- DINGLE, A.N., GILL, G.C., WAGNER Jr., W.H., and HEWSON, E.W. (1959): The emission dispersion, and deposition of ragweed pollen. Symposium Atmos. Diff. and Air Poll. Advances in Geophysics, Vol. 6, ed. F.N. Frenkiel and P.A. Sheppard, Academic Press, London, pp. 471.
- GILBERT, G.E. (1960) : Volumetric and gravity slide tests for air-borne ragweed and oak pollens at Columbus, Ohio. Ohio J. Sci., 50:60-70.
- GOODWIN, J.E., McLEAN, J.A., HEMPHILL, F.M. and SHELDON, J.M. (1957): Air pollution by ragweed: Medical aspects. Fed. Proc., 16 : 628-631.
- HARRINGTON, J.B., GILL, G.C. and WARR, B.P. (1959): High efficiency pollen samplers for use in clinical allergy. J. Allergy, 30 : 357-375.
- HEWSON, E.W. (1960) : Industrial air pollution meteorology. Ann Arbor, Michigan, Univ. of Michigan, Meteorological Laboratories. Univ. of Michigan Press, pp. 191.
- JONES, M.D. (1952) : Time of day of pollen shedding of some hay fever plants. J. Allergy, 23 : 247-258.
- OGDEN, E.C., and RAYNOR, G.S. (1960): Field evaluation of ragweed pollen samplers. J. Allergy, 31 : 307-316.
- SMITH, R.D. and BROOKS, P. (1954): The diurnal variation of air-borne ragweed pollen as determined by a continuous recording particle sampler and implications of the study. J. Allergy, 25 : 36-45.
- VOISEY, P.W. and BASSETT, I.J. (1961): A new continuous pollen sampler. Can. J. Pl. Sci., 41 : 849-853.

ABSTRACT

Hourly and daily counts of air-borne ragweed pollen, *AMBROSIA SPP*, taken with a volumetric sampler during the 1961 season at Ottawa, Canada, were compared with meteorological events. The time of daily peak concentration of pollen coincided with the time of decreasing relative humidity and development of a super-adiabatic lapse rate in the first 200 ft of atmosphere. Daily variations in pollen count were virtually completely dominated by the local ragweed population and microclimate but could be explained to a limited extent by variations in air mass. On occasions, gravity slide counts using a Durham type apparatus varied qualitatively with volumetric counts, but it was not possible to obtain a constant factor to convert gravity to volumetric counts.

ZUSAMMENFASSUNG

Die stündliche und tägliche Anzahl von Pollen des Jakobskreuzkrauts (*AMBROSIA SPP*) in der Luft (mit einem volumetrischen Sammler bestimmt) während der Saison 1961 in Ottawa, Kanada, wurde mit meteorologischen Daten korreliert. Die höchste Pollenzahl in der Luft fiel mit dem Abfall der rel. Feuchte zusammen und der Entwicklung eines überadiabatischen Gradienten in den ersten 65 m Höhe der Atmosphäre. Die täglichen Schwankungen der Pollenzahl wurden tatsächlich vollständig von der lokalen Verteilung der *Ambrosia spp.* und dem Mikroklima bestimmt und konnten nur in geringem Masse mit den Schwankungen der Luftmassen in Zusammenhang gebracht werden. Die Zahl der Pollen in durch Schwerkraft gewonnenen Proben fiel gelegentlich qualitativ mit den volumetrisch gewonnenen Proben zusammen; es war jedoch nicht möglich, einen konstanten Faktor zu berechnen, um gravimetrisch gewonnene Werte in volumetrische umzuwandeln.

RÉSUMÉ

Le nombre par heure et par jour, des grains de pollen de *AMBROSIA SPP.* dans l'air, mesuré par un collecteur volumétrique pendant la saison 1961 à Ottawa (Canada) a été comparé avec les données météorologiques. Le nombre le plus élevé correspondait à une chute de l'humidité relative et à un gradient superadiabatique s'élevant jusqu'à 65m d'altitude. La cause des variations quotidiennes du nombre des grains de pollen correspondait pratiquement à la distribution locale de *Ambrosia spp.* et au microclimat, et ne correspondait que dans une faible mesure avec les déplacements des masses d'air. Le nombre des grains de pollen obtenus par gravitation au moyen d'un appareil du type Durham coïncidait parfois qualitativement aux valeurs obtenues par un collecteur volumétrique, mais il n'a pas été possible d'établir un facteur constant, qui permet de transformer les valeurs gravimétriques en valeurs volumétriques.