

VIII. SUMMARIZED COMMENTS

VIII-1. Important results

VIII-1-1. The necessity of division into unpolluted and polluted SPM by using a selected smaller size sampler

The mixing ratio between two different SPM sources cannot be easily to estimate the determination. Because according to results of this investigation and supported by Japanese referenced issues, they show that the important effected factors for this mixed phenomenon in the atmosphere can be occurred as following items:

a) Meteorological conditions

In the different weather conditions according to be mostly brought by a strong wind power during a dry weather, unpolluted SPM (natural soil components) should be found even to the roadside of a central city area, and mixed them together with exhausted SPM of the mobile emission there.

b) Emission source as a natural soil

The result of a shortage rainfall in the cities are preventing from the green growing and covering on the naked soil area and there are also a lot of recognized under constructing places for the new and repaired roads and buildings.

c) A quality of surfaced soil

A famous phenomenon called “Yellow sand” in Japan is known of a long distance transportation from a desert sand in Monsoon season from the Gobi desert in China to Japan, it has almost happened this phenomenon every year. The distance of between them is around 2,600 km. It is also a well known the size of the sand is fine particles, that is why it can be suspended in the air for a long time.

1) Presuming unpolluted SPM ratio in the TSP concentration.

It is considered above the mentioned regarding three effected factors, the SPM ratio should be changed in a wide range and a variation.

The ratio of unpolluted SPM might be included some range, that is between 20 to 50% of Total Suspended Particulate (TSP) at roadside sampling data.

2) Evaluation of SPM data compared with AQS in Pakistan

In the case of investigated SPM data to be checked to the AQS level, it is a necessary to compare with mainly polluted SPM, because the purpose of setting up for the SPM Standard in foreign countries such as US, Japan and Europium Community is only monitored to check the polluted SPM conc. in the atmosphere.

3). Recommendation for selecting the polluted SPM sampler.

On the results of investigated PM 2.5 reference which being carried out in Japan and USA, it is a clearly recommended to use a PM 2.5 μ m sampler can be selected only the polluted SPM principally.

4). Detection of originated SPM sources and toxic chemicals concerning respiratory diseases in future.

Above mentioned, PM 2.5 μ m and PM 10 μ m samplers are both necessary to be set up at same sampling site, we can get a lot of information concerning the SPM originated sources, and also finding out the most toxic substances which are including the organic carbons such as a Diesel Emission Particulate (DEP) contains many different types of dangerous chemicals called the Polycyclic Aromatic Hydrocarbons (PAHs) which has confirmed the relationship between PAHs and the cause of a lung cancer.

Those chemicals are necessary to use the following analytical equipment, for instance, a Neutron Activation Analysis, an Atomic Absorption Spectrophotometer (AAS), a GC and a HPLC.

VIII-1-2. Setting up SPM and PM 2.5 Air Quality Standard

Consideration of different size of SPM shows the following Figure 46 has usually two peaks of the chemical group, the borderline of those two peaks separated by the size of around $2\mu\text{m}$.

The bigger size of SPM has more than $2\mu\text{m}$ which called coarse particles and less than that called Fine particles. The coarse particles are mostly coming from natural sources such as fine particles of soil component, sea salts and emission particles coming from the plants such as the pollens. Fine particles are coming from the process of combustion where existed in high moisture with the high temperature makes condensated particles at the primary stage of SPM formation, and providing coagulated with each particle together by accelerating of chemical reaction where existed the reactive gases. Figure 46 shows the schematic 2 peaks by size of SPM, it has been investigated that there are several scientific data shows by the size of SPM can be separated from polluted sources and natural source of SPM which divided by the size, so we can estimate the polluted SPM around $0.3 - 0.8 \mu\text{m}$ and also natural SPM is sized around $10 \mu\text{m}$.

In the urban area, there are components of those small particles of SPM which are coming from emission gas of vehicles, boilers and incinerators accompanied by the industrial activity. In the case of black soot is formed by incomplete combustion. It is also recognized the sulfate particle and organic aerosols produced by photochemical reaction with sunlight in the atmosphere.

Figure 46: Concept of different diameter of SPM in atmosphere

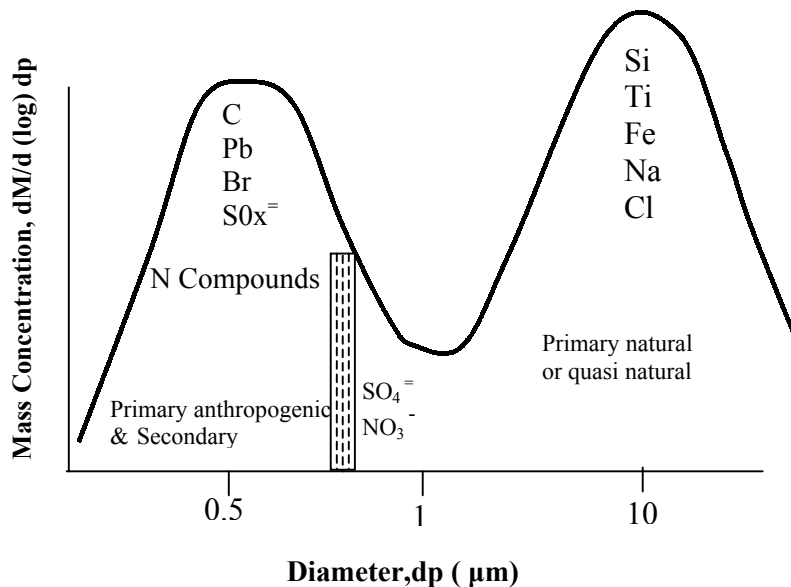


Table 35 shows the comparison of originated source and PM size between fine and coarse particles. Fine particle has generally more absorbing of moisture and solubility to water in comparison with coarse particle. Retention time of Suspended PM in the atmosphere, coarse particle is comparatively faster to descending by its own gravity, it is usually taking time in a minute to in a day, which is necessary descending them to the ground. Contrary, fine particles are suspended in a few weeks and transported distance is reaching from several hundred to several 1000 km, therefore, fine particles have a large opportunity to be respirated by human beings and making much influences to our health.

Table-35: Composition of ambient fine and coarse particles

	Fine particles	Coarse particles
Sources	Combustion (Coal, Oil, Gasoline, Diesel, Wood) Gas- to- Particles conversion (NOx, SOx, VOCs) Smelters, Mills etc	Resuspension of industrial dust and soil Suspension soil Biological sources Construction / demolition Ocean spray
Formation path	Chemical reaction Nucleation Condensation Coagulation Cloud/Fog processing	Mechanical disruption Suspension of dust
Composition	Sulfate Nitrate Ammonium Elemental carbon Organic compounds Water Metals (Pb, Cd, V, Ni, Cu, Zn, Mn., Fe, etc)	Suspended dust Coal and oil fly ash Crustal elements (Si, Al, Ti, Fe), oxides CaCO ₃ NaCl Pollen, mold, spores Plant, animal debris Tire wear debris
Solubility	Largely soluble, hygroscopic	Largely insoluble and non-hygroscopic
Lifetime	Days to weeks	Minutes to days
Travel distances	100s to 1000s of km	<to 10s km

Source: K. Mikio. , *Journal of Japan Society for Atmospheric Environment, The present state & future assignment of air pollution by particulate matter, 2002 Vol. 37 , No.2 Page 100.*

VIII-1-3. PM size shows their originated sources

Table-36: Different elements detection by the size of SPM and different method of measurement

Elements	PM 2.5 μm		SPM (10 μm)	
	FRM Average	SASS Average	FRM Average	FKS Average
Li	0.42	32.3	46.7	30.1
Mg	-	-	250	140
Ca	-	-	1190	610
Sc	0.085	-	0.22	0.17
V	3.9	4.8	5.5	3.7
Cr	-	-	130	130
Mn	8.2	41	42	26
Fe	450	920	1100	610
Zn	130	190	170	150
As	1.9	3.2	2.3	1.9
Rb	0.69	0.83	1.1	0.70
Cd	1.3	1.5	1.2	1.0
Tl	0.081	0.14	0.092	0.072
Pb	43	93	51	38
Organic carbon	6.9	6.3	8.1	5.5
Inorganic carbon	7.7	7.9	8.2	5.1
Carbon monitor				
i. Organic carbon	4.0	-	-	-
ii. Inorganic carbon	3.4	-	-	-

Source: Report on Fine SPM Investigation result concerning health, (Japanese Environment Sanitation Center) sponsored by Japanese Environmental Ministry, March 2002

Table-36 shows different elements detection by size of SPM and different method of measurement. Looking at Table 36 there is almost same weight of SPM into two sizes which are coming (guessing) from polluted sources and from natural sources such as Zn and Cd in almost same weight by the size. Comparatively bigger number of weight in size of 2.5 μm is to compare with 10 μm and these coming from polluted sources such as emissions from automobiles.

a). PM size of Black soot

Figure 46 shows the distribution of molecular weight among 0.02, 0.4 and 10 μm , the smallest size of SPM shows the peak around 0.02 μm . Each particulate makes unifying to bigger size which changes to around 0.4 μm after that becoming a general size shows two peaks in Figure 46. Figure 46 also shows that particles of SO₄ and NO₃ falls in the range between 0.5 and 1 μm as the dotted line of their existence in the atmosphere.

b). Secondary formation of PM in atmosphere

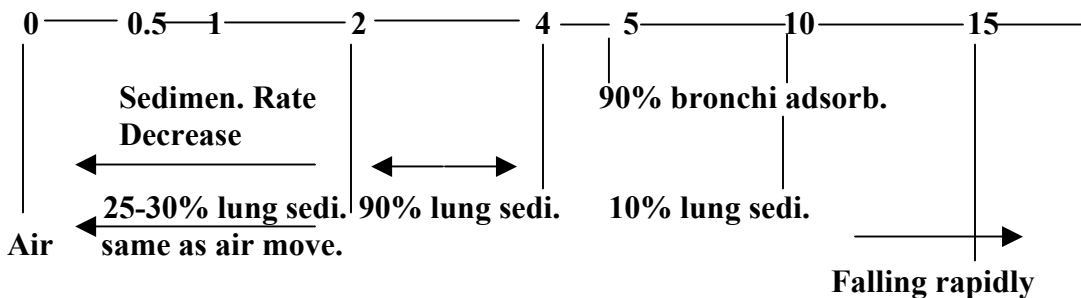
In the atmosphere, there are two different kinds of suspended particulate matter originated emissions from polluted sources such as industries, and also primary emitted air pollutants make the secondary formed particles are produced by chemical reaction in the air. On the other hand, it is considered that the suspended matter which are also coming from natural originated sources.

VIII-1-4. SPM size

According to the recommendation Report of the Minister of Health and Welfare Japanese Government from the Steering Discussion Committee on the Environmental Air Quality Standard on a SPM published in July 1971. Figure 47 shows that concerning the decision of a particulate size and a concentration after being studied on the investigation and the research for a long time which are not only considered Japanese experimental data, but also the Committee members been tried to collect the concerned issues among the US EPA and other countries at that time.

- (a). The Discussion Committee had reached the following conclusions that the transport behavior of the Suspended Particulates by their different sizes or diameter in ambient air, the deposition velocity in the case of less than $1\mu\text{m}$ diameter size, the behavior of it shows almost the same movement as that of air.
- (b). In the case of more than $10\mu\text{m}$, almost all particulates are caught by the membranes of a nasal and throat organ, due to these function of adsorption, these size of particulate usually cannot reach to the end cells of terminal parts of the lung tissues (where are not existed any cilia there).
- (c). In the case of the particle size up to $5\mu\text{m}$, 90% of them reach the end cell of the lungs, and become adsorbed on the surface of the cell as sediment.

Figure 47: Behavior and adsorption of SPM by particulate size in human respiratory tract.



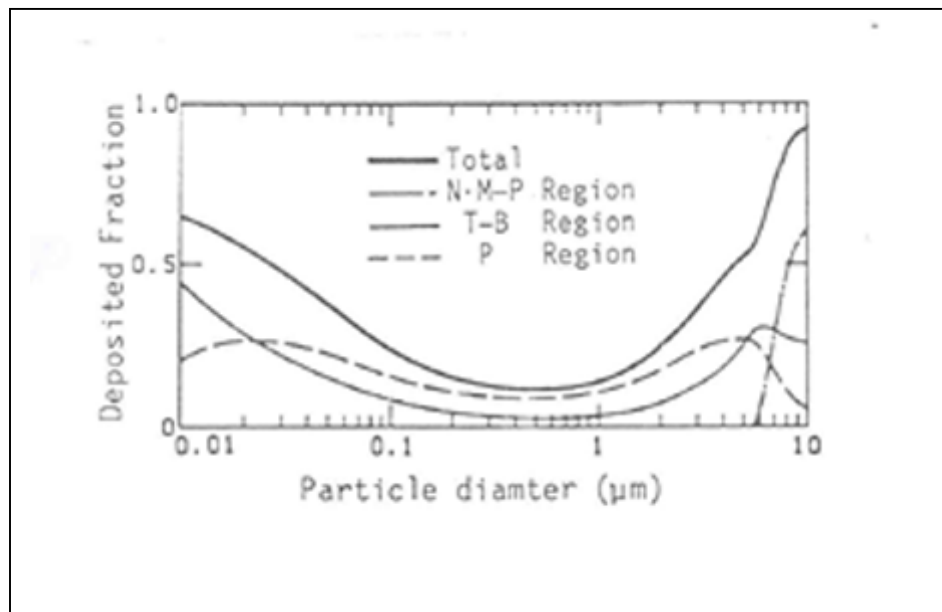
Notes: This consideration of Discussion (Fig.) did not pay any attention to chemical characteristics of the particulate substances, only had a viewpoint of physical aspects.

- (d). In the case of sizes between less than $5\mu\text{m}$, to more than $0.5\mu\text{m}$, it had a tendency to decrease gradually to the sedimentary ratio up to the size of $0.5\mu\text{m}$, the data showed that the ratio obtained was only 25 to 30% of sediment.
- (e). In the case of sizes smaller than $0.5\mu\text{m}$, it had a tendency to increase the sedimentary ratio goes down again.
- (f). In regard to the particulate sedimentary ratio on the surface of the end cell showed the highest sedimentary phenomena occurred at the size between $2 \sim 4\mu\text{m}$, and the minimum sedimentary ratio obtained at the size of $0.4\mu\text{m}$.
- (g). And also, it is considered that at the size of less than $0.4\mu\text{m}$, had a tendency to increase that ratio again.

Source: *Review of Pakistan Environmental Quality and Emission Standards Promulgated, JICA-Pak. EPA (No. 3), May 2, 2001*

United states has already adopted 2.5 PM as SPM AQS, and sampling time for which is 24 hours. Developed countries has been succeeded to shut out of the cigarette smoke from living circumstances, however SPM from emission gas especially diesel engine emission (D.E.P), containing black smoke particle and also some kinds of emission gas from incinerator still emitting high toxic substances such as Dioxin, (dioxin is attached with many different particles in atmosphere). Therefore the most important contaminated SPM is coming from diesel emission gas. Figure 48 below is example of sediment rate of SPM in respiratory organ. SPM sedimental ratio and part in the respiratory organ depend on the nature of particulate such as particulate size, chemical characteristics and absorbing the moisture, and also there is another element by the sucked air quantity by one breath, frequency of breath and condition of breathing.

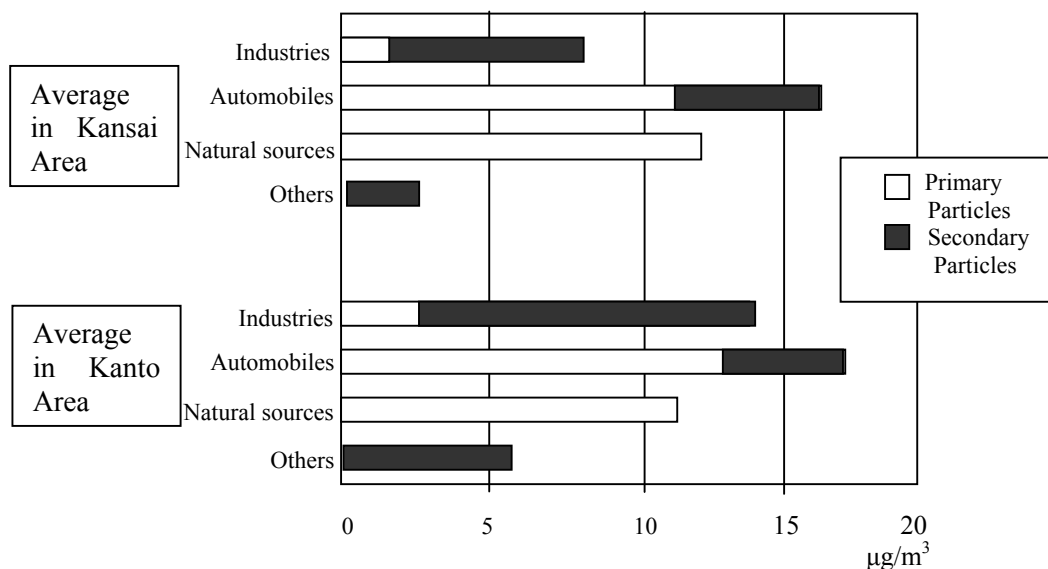
Figure 48: Deposition rates of particles in the human respiratory system



Source: *K. Mikio. , Journal of Japan Society for Atmospheric Environment, The present state & future assignment of air pollution by particulate matter, 2002 Vol. 37 , No.2 Page 102.*

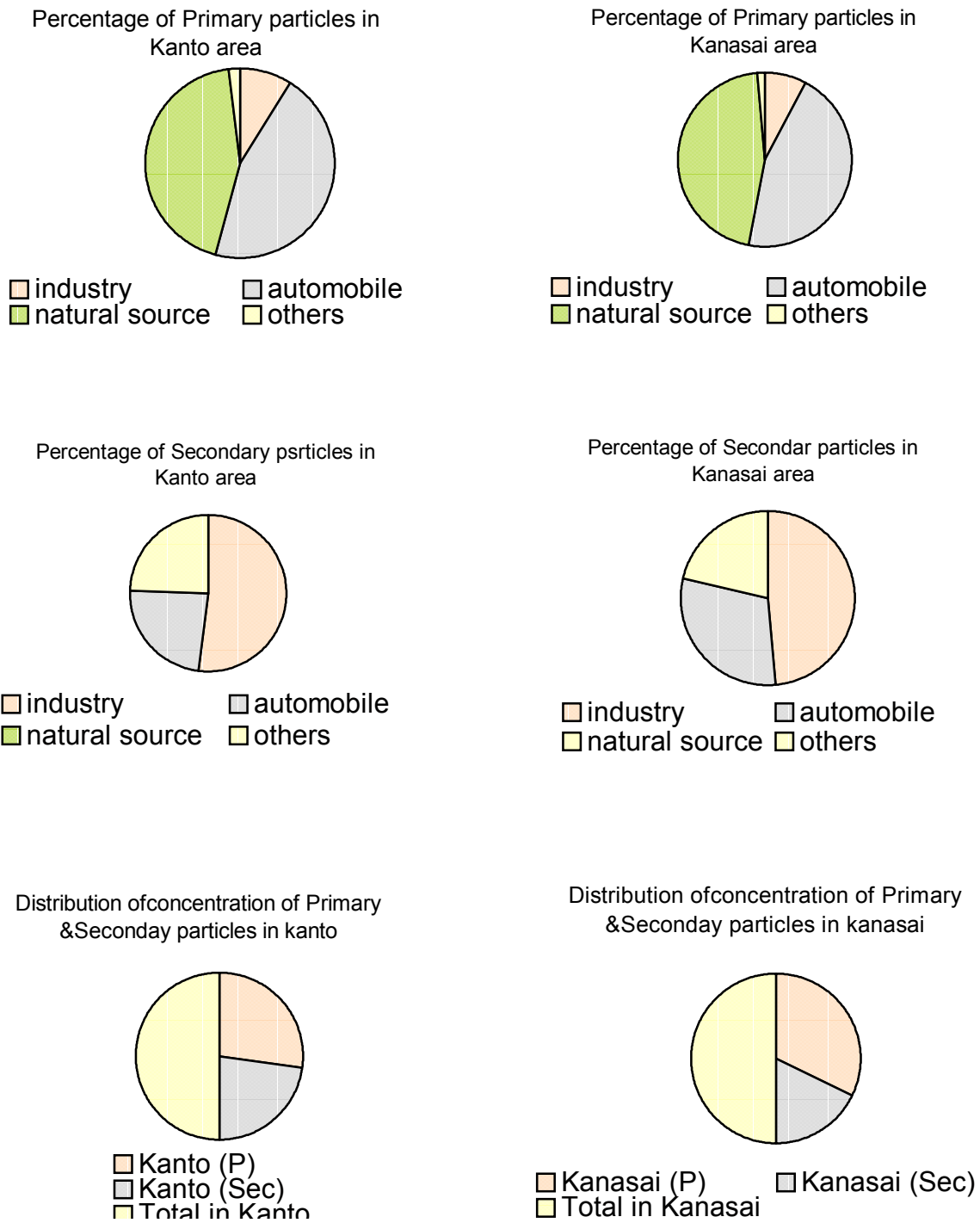
Figure 49 shows the estimation of contributed ratio by different emission sources where in highly populated in 2 areas. According to this Figure, primary particles coming from mobile sources especially black particle containing mainly as Elemental carbon from diesel emissions are found in generally originated sources. On the other hand, secondary particles which converted to particulate formation in the atmosphere, reaching to roughly about 40 %. These secondary particles are mostly formed at less than 1 μ m diameter in size. Figure 50 shows the percentage of primary and secondary particles in two selected areas in Japan.

Figure 49: Source contribution of particulates estimated by polluted sources in Japan (1994)



Source: K. Miki. , *Journal of Japan Society for Atmospheric Environment, The present state & future assignment of air pollution by particulate matter, 2002 Vol. 37 , No.2 Page 100.*

Figure 50: Percentage of Primary & Secondary particles in two selected areas in Japan



VIII-2. Improving tasks

1). Maintenance of temperature

Constant air conditioning space for the filter paper. The purpose of pretreatment for weighing the sampling papers should be kept in the same condition of air, such as $20\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ temperature and $50\% \pm 2\%$, before sampling for 24 hrs and after for 48 hrs. the filter pretreatment room, space is required around $2\text{m}^2 - 4\text{ m}^2$ wide with several fold shelves for put on each filter paper at horizontal level. And if it is possible to install the chemical balance close to this space, the weighing work is operated and easily smoothly.

2). Chemical Balance detectable level

Pak-EPA Laboratory is installed the sensitivity of chemical balance has only 0.1mg at minimum detection. For this kind of study investigation, it is necessary to use more high sensitivity of a chemical balance for example, detectable level is less than 0.001mg.

IX. RECOMMENDATIONS

IX-1. Importance of Setting up SPM and PM 2.5 AQS

1). SPM EAQS

Firstly it should be set up of SPM AQS urgently, because of getting the contaminated result in big cities warned us the level of SPM has already reached to critical conc. which was not only high level of SPM but also those SPM has containing a lot of toxic substances to human health such as PAHs which attached with elemental carbon particles that are called commonly DEP (Diesel Emission Particulate).

This time investigation, it couldn't analyze any organic hydrocarbon component if we could measure this several components of organic compounds, we were getting a strong impression of those toxicity near by the roadside living circumstances.

Smaller size of SPM is more effecting to human health under the influence of environmental conditions. Concerning SPM AQS in Japan, the SPM defined as the 100% of 10 μ m size, which differ from category PM10 in which is located at 50% of 10 μ m shows a high peak. Therefore one hour average AQS is determined at 0.2mg/m³, and one-day average standard should be less than 0.1mg/m³, these shows Japanese and USA Air Quality Standards at this moment.

Table-37 shows the EQS of PM10 and PM2.5 in two countries which should be referred to be set up the Standard for this country.

Table-38 shows the EQS of SPM in seven countries and WHO Recommendation Level as another referred data for Pakistan.

Table-37: Environmental standards for Particulate Matter in Japan &USA

Average time	Size range	Concentration level	Evaluation of environmental quality standards
Japan 1 hour mean value for a day The value for an hour	$\leq 10\mu\text{m}$ (SPM)	100 $\mu\text{g}/\text{m}^3$ 200 $\mu\text{g}/\text{m}^3$	The 98 th percentile for one year of daily average should be less than 100 $\mu\text{g}/\text{m}^3$ and the daily average should not exceed continuously 100 $\mu\text{g}/\text{m}^3$ more than 2 days.
U.S.A (New PM10) 24 hours Av. Annual Av.	$\leq 10\mu\text{m}$ (PM-10)	150 $\mu\text{g}/\text{m}^3$ 50 $\mu\text{g}/\text{m}^3$	Three year average of 99 th percentile for 24 hour PM-10 mass should be less than 150 $\mu\text{g}/\text{m}^3$. Three year average of yearly concentration should be less than 50 $\mu\text{g}/\text{m}^3$.
(New PM 2.5) 24 hours Av. Annual Av.	$\leq 2.5\mu\text{m}$ (PM-2.5)	65 $\mu\text{g}/\text{m}^3$ 15 $\mu\text{g}/\text{m}^3$	Three year average of 99 th percentile for 24-hour concentrations should be less than 65 $\mu\text{g}/\text{m}^3$. Three years annual average should be less than 15 $\mu\text{g}/\text{m}^3$.

Source: K. Mikio. , *Journal of Japan Society for Atmospheric Environment, The present state & future assignment of air pollution by particulate matter, 2002 Vol. 37 , No.2 Page 102*

Table- 38: Comparison of SPM AQS in different countries

Name of Country	1 hr.	8 hrs.	24 hrs.	1 year
Pakistan				
USA 10 µm		150	50	
Japan 10µm	200		100	
Saudia Arabia 15 µm			340	80
Mexico 10µm TSP			150 275	80
Chile TSP			260	80
UAE 10µm			150	
Kuwait 10µm			350	90
WHO Recommended level	50		120	

Source: *Pakistan Environment Air quality & Emission Standards, JICA –Pak EPA. 2001*

2). PM2.5 EAQS

a) Sampling by the size separator can be available roughly divided into polluted and unpolluted SPM origination

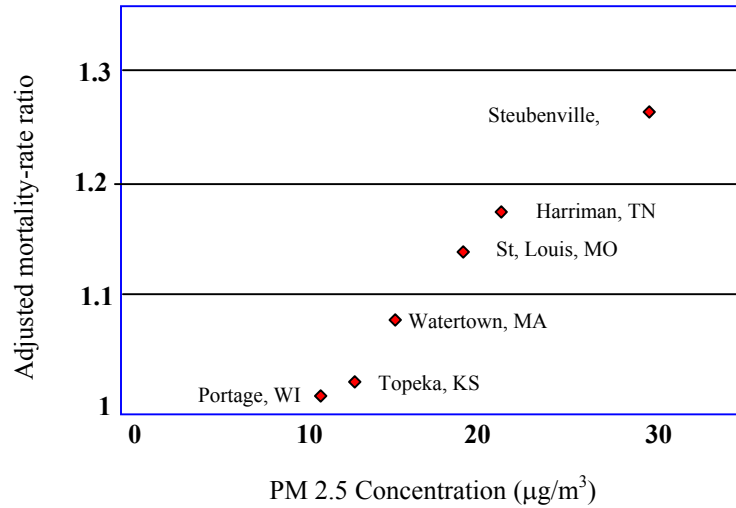
According to being mentioned in the importance of 2.5 measurement in this country, high concentration of unpolluted SPM are measured mixed together at roadside in the cities. Technical reference data recommended that to measure only originated of polluted SPM by using 2.5µm air sampler.

And also it is shown the Figure 51, it is easier understanding how much close relationship between a mortality and PM 2.5 which has linear damage showing in adjusted mortality rate in the increasing of PM 2.5 in 6 cities in United States.

The morality rate has been adjusted by (taking out) another function of smoking i.e. called Adjusted morality rate. According to this investigation, it has cleared the fact that PM 2.5 is more dangerous of SPM in consideration of ratio for causing the respiratory diseases, bronchitis and bronchial asthma.

It is cleared that 2.5 SPM has higher caused of respiratory diseases that surely reach to the deep bottom of lung tissue and sediment there permanently. According to this investigated study and epidemiological research, US.EPA had set up a new AQS guidance is included both PM sizes to be measured i.e. PM10 and PM2.5 since in 1987, and PM 2.5 has adopted as official AQS in 1997.

Figure 51: Health effect of PM 2.5 estimated adjusted mortality rate as function of 2.5 concentrations



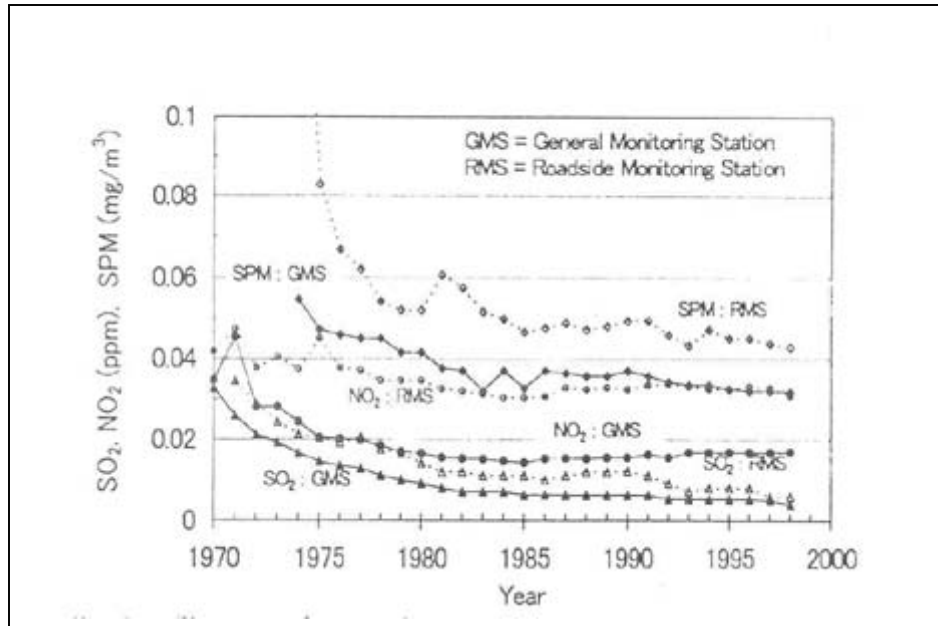
Source: K. Mikio. , *Journal of Japan Society for Atmospheric Environment, The present state & future assignment of air pollution by particulate matter, 2002 Vol. 37 , No.2 Page 103.*

On the other hand in Japan, the actual measured SPM concentration by general monitoring stations and especially mobile emission gas monitoring stations have not improved since 15 years ago. However, the achievement ratio within the SPM AQS has been still lower and is required to improve the concentration of the percentage for the SPM Standard.

It has studied to investigate the SPM size summarized in US EPA, because it has been proved that smaller SPM size such as 2.5µm has more high dangerous influence which observed in the lung tissue and also has the mentioned above, the toxic components including in SPM have a high percent of smaller size particle.

Figure 51 shows us two important facts relationships between SPM and health effects, the first one is the multiplier effects by in high conc. of SPM and existing with SO₂ and NO₂ together at the atmosphere. The second one is shown in the Figure 52, SPM conc. at road side monitoring stations are usually 20-30 % in higher than that of general monitoring stations (residential area), and also PM2.5 conc. is always higher ratio occupied to compare with general monitoring data in SPM.

Figure 52: Change of annual average concentration of SO₂, NO₂, and SPM



Source: K. Miki. , *Journal of Japan Society for Atmospheric Environment, The present state & future assignment of air pollution by particulate matter, 2002 Vol. 37 , No.2 Page 103.*

IX-2. SPM in Pakistan cities has an originated natural soil together

SPM in Pakistan cities have a high originated natural SPM concentrations, according to result of this investigation, the sampler of smaller SPM size has been used at the size of 7.07 μ m and SPM, there are much different meaning of size sampling between 7.07 and PM2.5, however, it has showed the tendency of originated source between polluted SPM and natural originated SPM.

Table [7 (c) & 13 (c)] show the percentage of PM 7.07 among the SPM in two cities, in the case of Lahore data show the high conc. of SPM percentage are included in PM 7.07 at 68.7 and 96.6% at the roadsides to compare with unpolluted sites at only 48.08%, and also the roadside of Rawalpindi, PM7.07 occupied 37.99 to 59.45% among SPM, but to compare with unpolluted sites those smaller size of SPM percentage show in higher than unpolluted. It might be getting higher rate of smaller size SPM among SPM by using PM 2.5 μ m sampler.

We are expecting to use the PM2.5 μ m sampler (Flow rate should be larger than 16.67 l/min). In the future SPM investigation will implement by the Pak-EPA to make confirmation of classification between TSP and PM2.5 by each near the roadside.

IX-3. Measurement method for SPM and PM2.5

PM 2.5 and SPM must be measured by the standard method which shown in Table-39, this tentative measurement method at PM 2.5 was shown by the Japanese Ministry of Environment with a tentative operation manual in September 1999.

Main different point between PM2.5 and SPM is to improve the SPM size smaller than before, according to informing the scientific result between SPM size and health effect. The information concerning components of smaller size are including Diesel Emission Particulate (DEP) which is containing at high conc. of PAHs. Which is serious damage to the respiratory diseases. Therefore the importance of PM2.5 measured has increased a necessity for the tool of SPM measurement.

PM 2.5 sampler is selling in commercial base in USA and Japan and may be in European countries. At the moment, the price is very expensive so we cannot use for this investigation. But after the sampler using more popularity should be in the economical price and easier handling in any country.

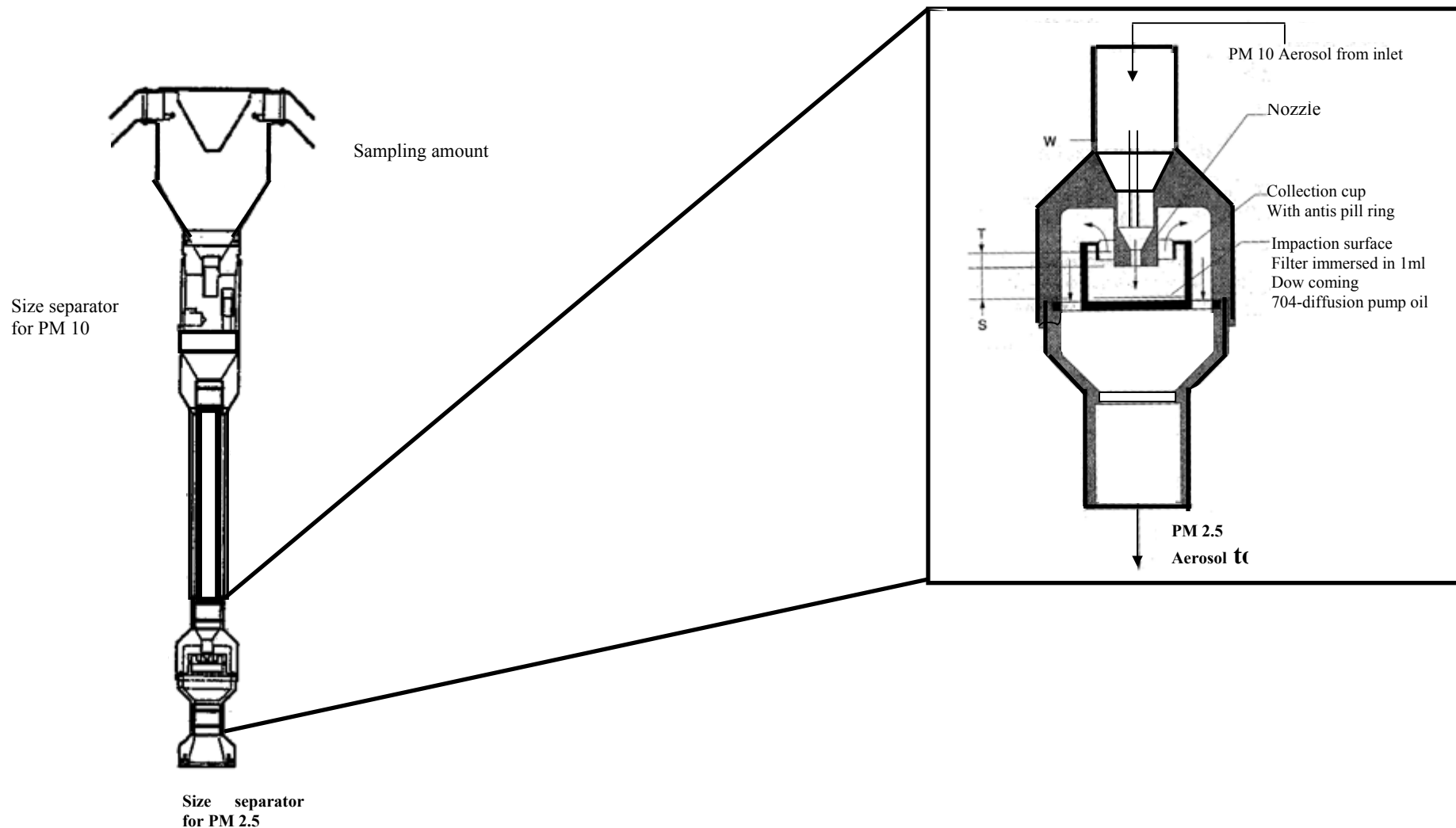
Table-39: Measurement method for SPM and PM 2.5

		PM 2.5 tentative manual	SPM
MEASUREMENT METHOD		Gravimetric analysis by low volume air sampler	Gravimetric analysis by low volume air sampler
SPECIFICATION OF PARTICULATE SIZE		50% of 2.5 µm size cut designated by particle size specification.	100% cut of 10 µm
MEASUREMENT RANGE		Minimum quantitative min 2 µg/m ³ Maximum quantitative <200µg/m ³	Not determined
SAMPLING TIME		23-24hrs	Not determined
FILTER	<ul style="list-style-type: none"> • SHAPE • SIZE (Outer diameter) • SIZE (Inner diameter) • MATERIAL • PORE SIZE • THICKNESS • REQUIRED PERFORMANCE 	<ul style="list-style-type: none"> ▪ Round shape with support ring ▪ 46.2 ± 0.25mm φ ▪ 38.82 mm φ ▪ PTFE ▪ 0.2µm ▪ 30-50µm ▪ To collect more than 99.7% of 0.3µm size 	<ul style="list-style-type: none"> Round shape 110mm φ or 47 mm φ 100mmφ or 42mm φ Not determined quantity only showing performance Not determined Not determined Primary stage of correcting ratio is more than 99% of 0.3µm size.
SAMPLER	<ul style="list-style-type: none"> • REQUIRED DESIGNATED ABILITY • SIZE SEPARATION • INTRODUCING PIPE OF SAMPLER • FILTER HOLDER • FLOW RATE CONTROL PART 	<ul style="list-style-type: none"> ▪ Sampling flow rate and other operating parameter should be self-controlled. Recording and showing the numbers of function for flow rate, temperature & Pressure. ▪ Control function to make fluctuated temperature within 5° C. between filter part & outside temperature ▪ Impactor system ▪ Designation of material, finishing & setting degree of the pipe. ▪ Designation for tighten the parts such as flame, net & packing. ▪ Controlled air-sampling quantity at 16.67l/mm which introduced to size separation part. ▪ Control the temperature & pressure by mass flow controller within ±2% after operation of flow rate measured. ▪ Variation of flow rate should be within ± 5 % & coefficient of variation within 2% in 24 hours sampling. 	<ul style="list-style-type: none"> ▪ No specification item. ▪ Multi stage type or cyclon type ▪ Nil (in case of Direct Sampling) ▪ Designation for tighten the parts such as flame, net & packing . ▪ Use of level differential pressure bulb, necessary to check for arrangement in keeping in case of at 20l/m, when variation is more than ±7%.

SAMPLER	<ul style="list-style-type: none"> • FLOW RATE MEASUREMENT • PRESSURE MEASUREMENT PART • TEMPERATURE MEASUREMENT • SUCTION PUMP • RECORDING FUNCTION 	<ul style="list-style-type: none"> ▪ Measured by mass flow meter. instant flow rate, average flow rate , coefficient of variation at sucking flow rate, total flow rate should be shown. ▪ Shown measurement of pressure in sampling time at air sucking part. ▪ Shown the temperature measurement at the surface of filter part and out side temperature. ▪ Eccentric type of rotor system, diaphragm system. High degree of vacuum ability. Flow rate is large. Small pulsing movement. Long life durability. Low level of noise ▪ Instantly, average flow rate. Out side temperature and surfaced filter part. Recorder has function of recording ability in the case of out range setting. 	<ul style="list-style-type: none"> ▪ Use of float type of area flow meter or mass flow meter. In case of area flow meter is used after calibration of resistant loading. ▪ Not designated ▪ Not designated ▪ Eccentric type of rotor system, diaphragm system. High flow rate. Keeping in good setting flow rate. Small pulse rate & less emitting heat ▪ Not designated
SETTING CONDITION	<ul style="list-style-type: none"> • SETTING CONDITION • RELATIVE HUMIDITY • WEIGHING • CHEMICAL BALANCE • BLANK • PROTECTION OF STATIC ELECTRICITY 	<ul style="list-style-type: none"> ▪ Temperature in 22~23° C ▪ 50 ± 5% ▪ Weigh after keeping for more than 24 hrs. ▪ Sensitivity weigh after 1µg. ▪ Preparing for travel blank and lab blank. ▪ Showing counter measured procedure is such as taken inside sealed system, and installation of ionizer type of chemical balance 	<ul style="list-style-type: none"> ▪ Temperature in 20° C. ▪ 50% only ▪ Weigh after keeping between 16 ~ 48 hrs.. ▪ Sensitivity has weigh after 10 µg ▪ Not designated ▪ Not designated
CALCULATION	<ul style="list-style-type: none"> • SAMPLING FLOW RATE 	<ul style="list-style-type: none"> ▪ Accuracy with in ± 2% for the standard flow rate. 	<ul style="list-style-type: none"> ▪ Making collaboration curve for inserting by 150mmHg resistance.

<ul style="list-style-type: none"> • HEIGHT OF SAMPLING AMOUNT • ACCURACY CONTROL 	<ul style="list-style-type: none"> • 2.0 ± 0.2m setting installed ground level considerable not effecting from particulate of ground • Implementing accuracy to start operation manual. • Showing the record item, record of accuracy control, items should be written in result. 	<ul style="list-style-type: none"> ▪ 3 –10m height from ground level ▪ Nil
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Figure 53: PM 2.5 separated designated part by US.EPA Standard Method and magnified structure at 2.5 separator



EPA has not yet authorized any automatic standard sampler of PM 2.5. However EPA has already authorized the PM10 standard sampler such as TEOM (Tapered Element Oscillating Microbalance) and BAM (Bata Attention Monitor) shown Table-40.

Table-40: Classification of PM 2.5 continues monitoring sampler by US.EPA

Classification by principle measurement	The name of continues automatic air sampler
a) Mass & Mass equivalent	<ul style="list-style-type: none"> • Tapered Element Oscillating Microbalance (TEOM) • Piezoelectric Microbalance • Pressure drop tape sampler (CAMMS)
b) Visible light searching	<ul style="list-style-type: none"> • Nephelometer • Optical Particle Counter (OPC) • Condensation Nuclei Counter (CNC) • Aerodynamic Particle Sizer (APS) • Light Detection And Ranging (LIDAR)
c) Visible light absorption	<ul style="list-style-type: none"> • Aethalometer and particle soot/ absorption photometer • Photo acoustic spectroscopy
d) Electrical mobility	<ul style="list-style-type: none"> • Electrical Aerosol Analyzer (EAA) • Differential Mobility Particle sizer (DMPS)

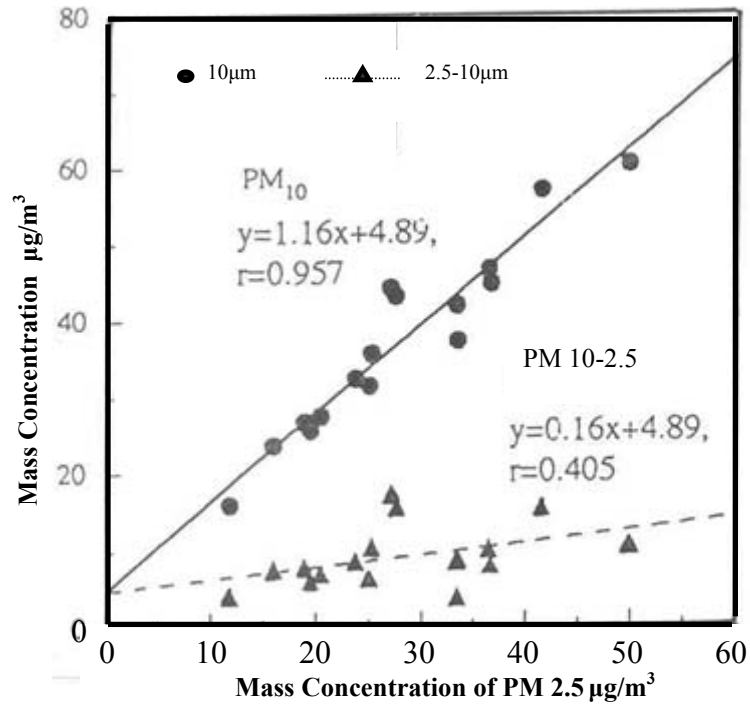
Table 41 shows the one-hour average data of 24 hrs average measured by FRM and other three measurement methods, which are implemented data in summer and winter season in 2000. The table shows the slope of relative coefficient and primary recurrence formula. According to compare with data, TEOM & BAM in summer and winter are both similar to a relative coefficient should be more than 0.98 to the standard of FRM, but light scattering method shows a relative coefficient measured in winter shows a little inferiority coefficient as compare to standard FRM.

Table-41: Relative comparison of PM 2.5 in mass concentration by FRM & PM2.5 automatic samplers

Standard method	Comparative Measurement equipment	Summer 2000($n^{\infty}=20$)		Winter 2000($n^{\infty}=16$)	
		Slope of primary recurrence formula	Relative coefficient	Slope of primary recurrence formula	Relative coefficient
FRM	TEOM	1.04	0.98	0.88	0.98
	BAM	1.27	0.98	1.14	0.98
	BMA Light scattering	1.32	0.97	0.79	0.87

Note: TEOM: Tapered element oscillating microbalance
 BAM: Bata Attention Monitor

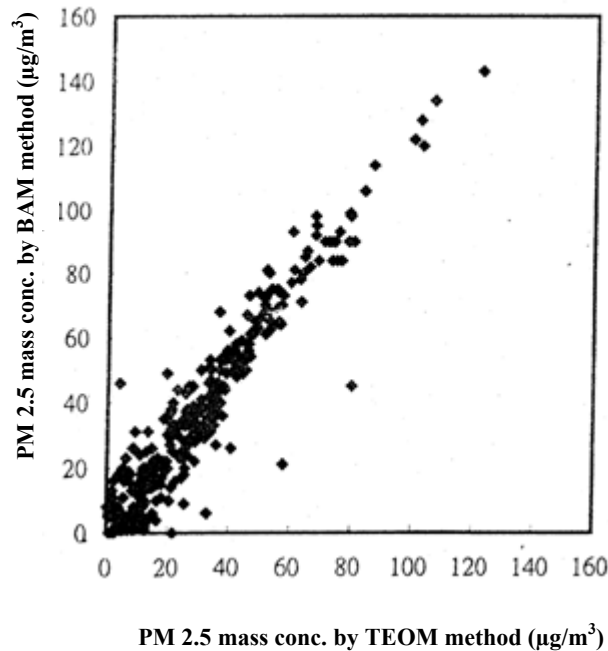
Figure 54: Correlation between mass concentration of PM 2.5 and PM 10 or PM 10 ~ 2.5 collected from July 1997 to August 1998



Source: Tomohiro .K, Masaki .I., *Characteristics & seasonal variations in mass multi-element concentrations of ambient fine and coarse particles*, *Journal of Japan Society for Atmospheric Environment*, 2000, vol.35, No.5, p 290.

Figure-54 shows that the fine and coarse particles in ambient air measured in Kufo in Japan. According to oblique line between mass concentrations of PM 2.5 and PM10, there are showing a very good relative coefficient ($r = 0.96$), therefore it can be estimated from the PM10 measured concentration to the PM 2.5 concentration.

**Figure 55: Comparison to PM 2.5 mass concentrations by the data of TEOM & BAM
(1 hour value in winter 2000)**



Source: Toyohiko NEZU, Kazuhiko SAKAMOTO, *Measurement method for fine particles (PM_{2.5}) of Mass conc. in Ambient Air*, *Journal of Japan Society for Atmospheric Environment*, Vol. 37, No. 1, 2002.

Figure 55 shows the PM 2.5 mass concentration measured in winter of 2000, TEOM/BAM & TEOM /light scattering automatic method show in a good relative relation, and also a relative coefficients are shown each 0.9 (n= 632) and 0.86 (n =695).

Generally measured data in comparison with TEOM, BAM data show a little bit higher to TEOM data and also a light scattering automatic equipment shows to compare with TEOM. Looking at Figure 55 concerning distribution of dots of TEOM and BAM where in higher concentration area shows the dots located on the line of primary recurrence line, but in lower concentration area, the distribution of dots are fluctuated.

IX-4. Following tasks should be considered when PM2.5 adopted as an AQS

1. There is not established an adequate PM2.5 measurement method yet, because of size separator of a high volume air sampler being used at present. The standard method should be developed to classify each different size of a diameter easier.
2. On the sampling condition, the size sampling air volume is limited range, so that reason, the volume might be decreasing and it may worst effect to accurate size analysis. It is necessary for improving a bigger volume sampler to be developed immediately.
3. SPM and 2.5 μm samples should be set for sampling at same time and same place together.