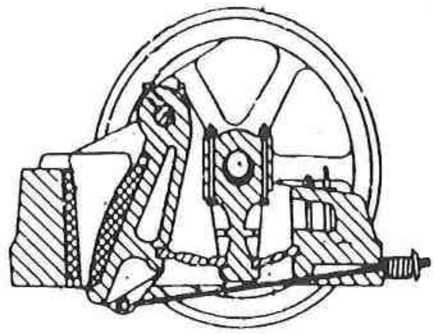
ASSESSMENT OF DUST EMISSIONS FROM STONE CRUSHING INDUSTRY

Sponsor

TAMIL NADU POLLUTION CONTROL BOARD



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NAGPUR 440020

JANUARY 1998

Foreword

Stone Crushers are small scale industries in the unorganised sector. They provide the basic material for road and building construction. They are highly labour intensive.

The various unit operations involved in stone crushing namely size reduction, size classification and transfer operations have the potential to emit process and fugitive dust.

With sponsorship from the Tamil Nadu Pollution Control Board, the National Productivity Council has demonstrated a dust containment and suppression system for the stone crushers. Most of the stone crushers have adopted the NPC System which is quite effective in controlling the air pollution.

With a view to assess the adequacy of the NPC control system and to review the extant siting criteria for stone crushers, the Tamil Nadu Pollution Control Board approached NEERI, which thereupon undertook a detailed study at Pammal and Alathur Gate during September - October 1997. The findings of NEERI are presented in this report. As the study was conducted during premonsoon period it is essential that the study be repeated during summer season when wind velocities would be higher.

The generous assistance of the crusher owners at Pammal and Alathur Gate is gratefully acknowledged. Our sincere thanks are also due to the Tamil Nadu Pollution Control Board for sponsoring this work.

Nagpur 20
January, 1998

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1.0 Introduction

1.1 Background

Crushed stone, as the name implies, is mined in an open quarry or pit and crushed to the desired product size. After transfer to the processing plant by various means, quarried stone is subjected to various size reduction, size classification, and transfer operations, all of which have the potential to emit process and fugitive dust.

With the support of the Tamil Nadu Pollution Control Board, the National Productivity Council has demonstrated a suitable dust suppression and containment system for stone crusher units. Most of the crusher units in Tamil Nadu have adopted the NPC system and hence the TNPCB approached NEERI to evaluate the adequacy of the pollution control measures and to establish a siting criteria for stone crushers with respect to their distance from residential areas and National and State Highways.

1.2 Nature of the Stone Crushing Industry

Stone crushers are small scale industries with low capital investment (varying between Rs 5 to 10 lakhs). Stone crushing in India is basically a labour intensive operation where the loading of stone into the crusher, conveying the product material from separating screens, loading and unloading operations are performed manually. The production capacity of stone crushers varies from 30-300 tonnes/day (8 hours operation).

1.3 Location of Stone Crushing Industry

Crushed rock is basically a construction material (e.g.) road bed, paving materials and concrete mixing), and distances between the quarry and processing plant and its point of use must be kept to a minimum to avoid high transportation costs. Thus many crushed stone operations tend to be located relatively near populated areas. Further more since the life of a quarry will be a number of decades many such operations that were originally located in undeveloped or rural areas may eventually be surrounded by residential developments, with homeowners complaining about dust settling on their property.

The distribution of stone crushing units in Tamil Nadu is given in **Table 1.1**. Out of a total of 1191 units only 16 are reported to be located in industrial areas 190 units are situated along National or State Highways.

1.4 Process Description

Stone crushing is a mechanical operation by which large size stone as mined from quarries, in the size range of 200-300 mm, is crushed to smaller usable sizes, generally 6,15,25 mm. The crushed material is segregated size wise by screening and is then ready for despatch and use in road and building construction.

Quarried stone is normally delivered to the processing plant by truck and is dumped in storage pit or bunker. The stone crusher is usually a jaw crusher.

The crushed material from the jaw crusher is separated into various fractions i.e. 25 mm, 15 mm, 6 mm and stone dust in a rotary screen. The oversized material is sent back to the jaw crusher for further crushing, reducing the size of the stones to below 20 mm. The different sized products are transferred from the bottom of the screen by belt conveyors to the stockpiles and further transported, usually by trucks to the consumer.

1.5 Nature of Emissions from the Stone Crushers

The only pollutant emission of concern from stone crushing is particulate matter. Emissions from stone processing should be considered to be fugitive as the sources are not vented to a bag house or are contained in an enclosure with a forced air vent or stack.

Emission points for dust release from stone crushing typically include the following :

* Loading of trucks
* Truck travel on dusty roads
* Fugitive dust loss from trucks
* Dumping into crusher
* Crushing

* Screening
* Transfer points on conveyor systems
* Loading onto storage piles from conveyors
* The wind blowing dust from storage piles and open conveyors.

1.6 Air pollution control measures

Control measures for reducing or eliminating fugitive emissions from stone crushing plants include the following :

* Wetting of material or surfaces with water with or without surfactants or foaming agents.
* Covering open operations to prevent dust entrainment by the wind.
* Reducing the drop height of dusty material.
* Using hooding, industrial ventilation systems and dust collectors (e.g. bag houses) on dusty processes amenable to enclosure.

The CPCB stipulates the following standards for suspended particulate matter in stone crushing units :

The standards consist of two parts :

i) Implementation of the following pollution control measures

  a) Dust containment cum suppression system for the equipment
  b) Construction of wind breaking walls.
  c) Construction of the metalled roads within the premises.
  d) Regular cleaning and wetting of the ground within the premises.
  e) Growing of a green belt along the periphery.

ii) Quantitative standard for the SPM

The suspended particulate matter measured between 3-10 meters from any process equipment of a stone crushing unit shall not exceed 600 $\mu g/m^3$.

The National Productivity Council vide their report of 1995 has demonstrated a suitable dust suppression and containment system for the stone crusher units. The dust containment system comprises of building enclosures over the major dust emission sources so as to contain the dust within the housing. Only the rotary screen is considered for dust containment enclosures. It is not recommended to enclose the jaw crusher as frequent manual intervention and attention is required. The dust suppression system comprises of spraying of water as a fine mist through special mozzles over such dust generation sources as material transfer points.

1.7 Assessment of Dust Emissions

The study was conducted at two places selected by the TNPCB - one at Pammal in Tambaram Taluk of Kancheepuram District and the other at Alathur Gate in Kunnam Taluk of Perambalur District.

1.7.1 Study at Pammal

Source and Ambient Air Quality Monitoring

The study area at Pammal is located at a distance of 25 kms. to the southwest of Chennai City (**Figure 1**). There are 48 crushers located west of a quarry as shown in **Figure 2**. All the crushers have adopted the NPC pollution control system and are listed in **Table 1.2**. On the basis of a reconnaissance on Sept. 1, 1997 four stone crushing units were chosen for source sampling and 12 locations for ambient air quality monitoring. The ambient air quality locations were selected on the basis of the prevailing wind direction and wind speed and also giving due consideration to the historical wind rose for Chennai City (1969-91). 4 Respirable Particulate Samplers and 12 HI-VOL samplers were deployed for the work. At Kavasam Crushers both a HI-VOL sampler and a Respirable Particulate Sampler were operated. All the samplers were operated continuously for a period of 4 days from 4th October 1997.

The location of the source and ambient air quality monitoring stations is shown in **Figure 2** and indicated in **Table 1.4**. The study was conducted in three phases: 1. with all the crushers running, 2. with only one crusher running and 3. with no crusher running to account for the background emissions.

Micrometeorological Observations

A weather station consisting of a wind vane, a cup anemometer and a thermo hygrometer was stationed in an open space at a distance of 259 metres from Kavasam Crusher. Wind speed, wind direction, temperature and humidity were monitored hourly for a period of 10 days from 30th September 1997. The predominant wind directions were South East, West and South West.

1.7.2 Study at Alathur Gate

Source and Ambient Air Quality Monitoring

The study area at Alathur Gate is located at a distance of about 55 Kms. North of North West of Tiruchi (**Figure 3**). There are 4 crushers fitted with NPC designed dust containment and suppression system, located near the highway NH45, as shown in **Figure 4**. The crushers are listed in **Table 1.3**. On the basis of a reconnaissance on September 16, 1997, it was decided that source sampling would be carried out at all the four crushers and ambient air quality monitoring at 12 locations. At Murugan crusher both a HI-VOl Sampler and a Respirable Particulate Sampler were operated. The samplers were operated continuously for a period of three days from 16th October 1997. The location of the source and ambient air quality monitoring stations is shown in **Figure 4** and indicated in **Table 1.5.**

The study was conducted in three phases : 1. with all the crushers running, 3. with only one crusher running and 3. with no crusher running to account for the background emissions.

Micrometeorological Observations

The weather station was installed in an open space at a distance of 187m from the control station. Wind speed, wind direction, temperature and humidity were monitored every hour for a period of 5 days from 15th October 1997. The dominant wind directions were North East and North.

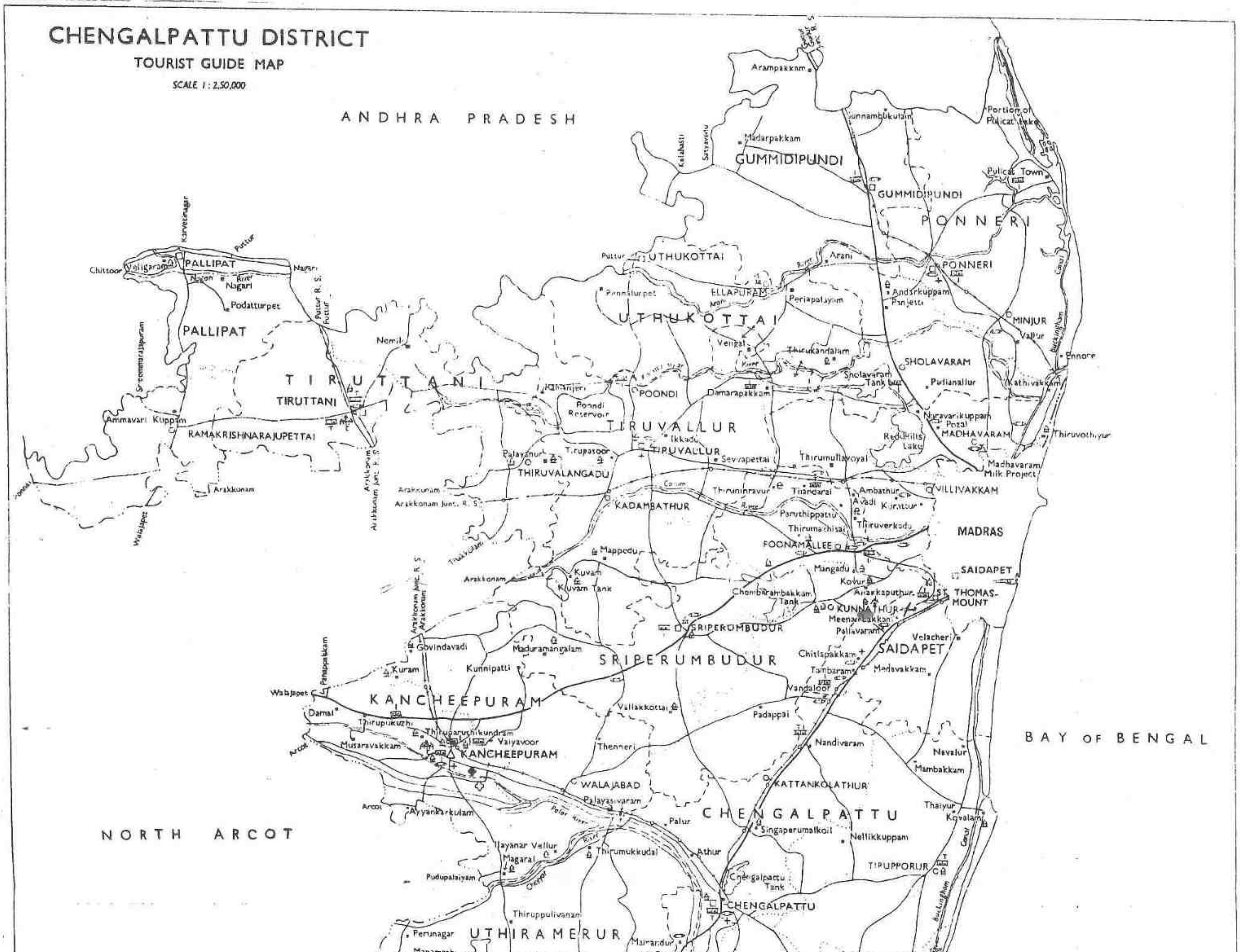
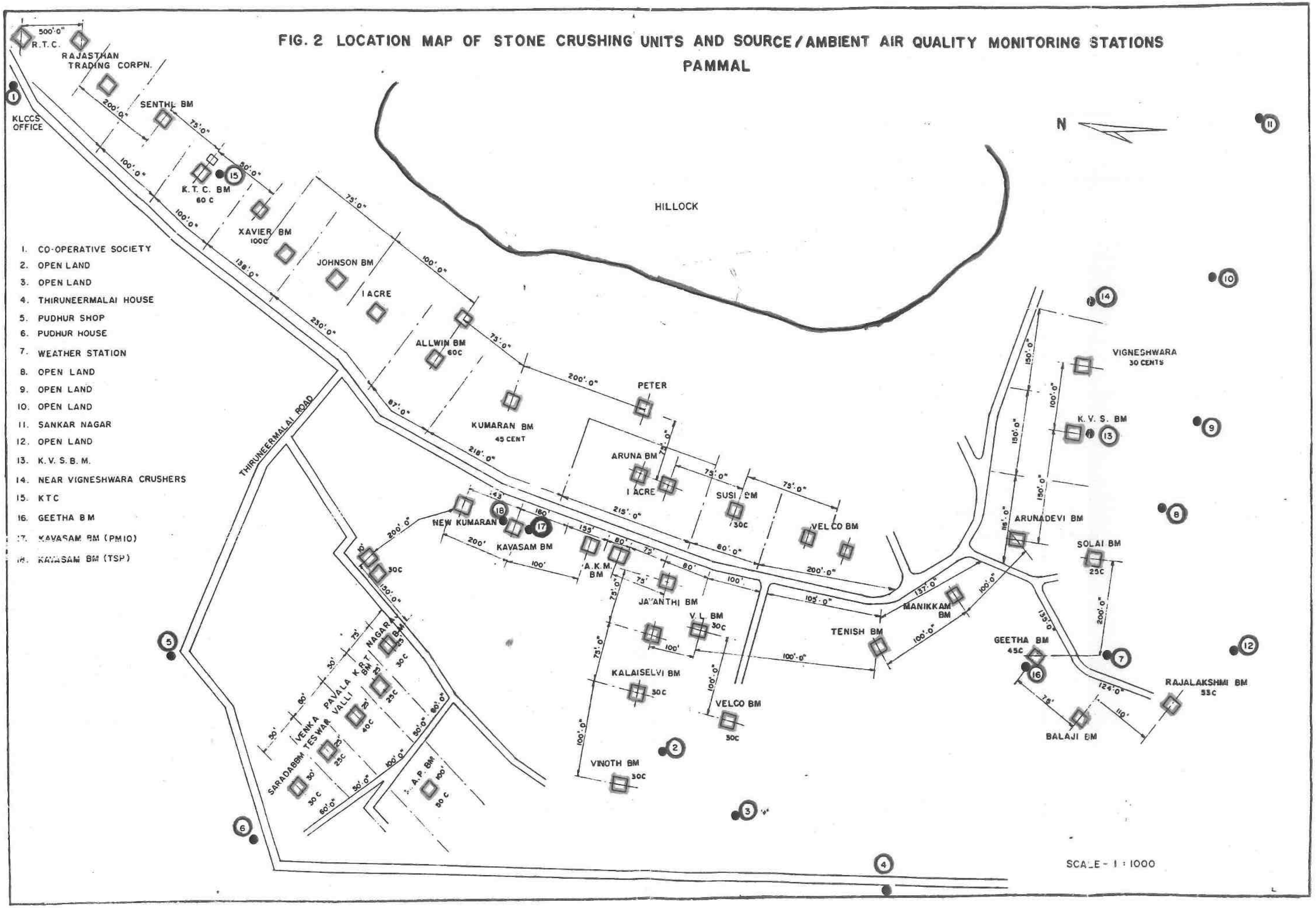


FIGURE 1 LOCATION OF PAMMAL STONE CRUSHING INDUSTRY ●

FIG. 2 LOCATION MAP OF STONE CRUSHING UNITS AND SOURCE/AMBIENT AIR QUALITY MONITORING STATIONS
PAMMAL



Taluk Name	No	Name of the Firka
VEPPANTATTAI	1	Pasumbalur
	2	Vengalam
	3	Valikandapuram
PERAMBALUR	1	Perambalur
	2	Kurumbalur
KUNNAM	1	Vadakkalur
	2	Varagur
	3	Kilapuliyur
	4	Kulakkalnatham
	5	Chettikulam
ARIYALUR	1	Ariyalur
	2	Nagamangalam
	3	Elakurichi
	4	Kilapalur
	5	Tirumanur
SENDURAI	1	Mathur
	2	Sendurai
	3	Ponparappi
UDAYARPALAYAM	1	Kovagam
	2	Andimadam
	3	Kundaveli
	4	Jayankondamcholapuram
	5	Udayarpalayam
	6	T. Palur
	7	Suttamalli

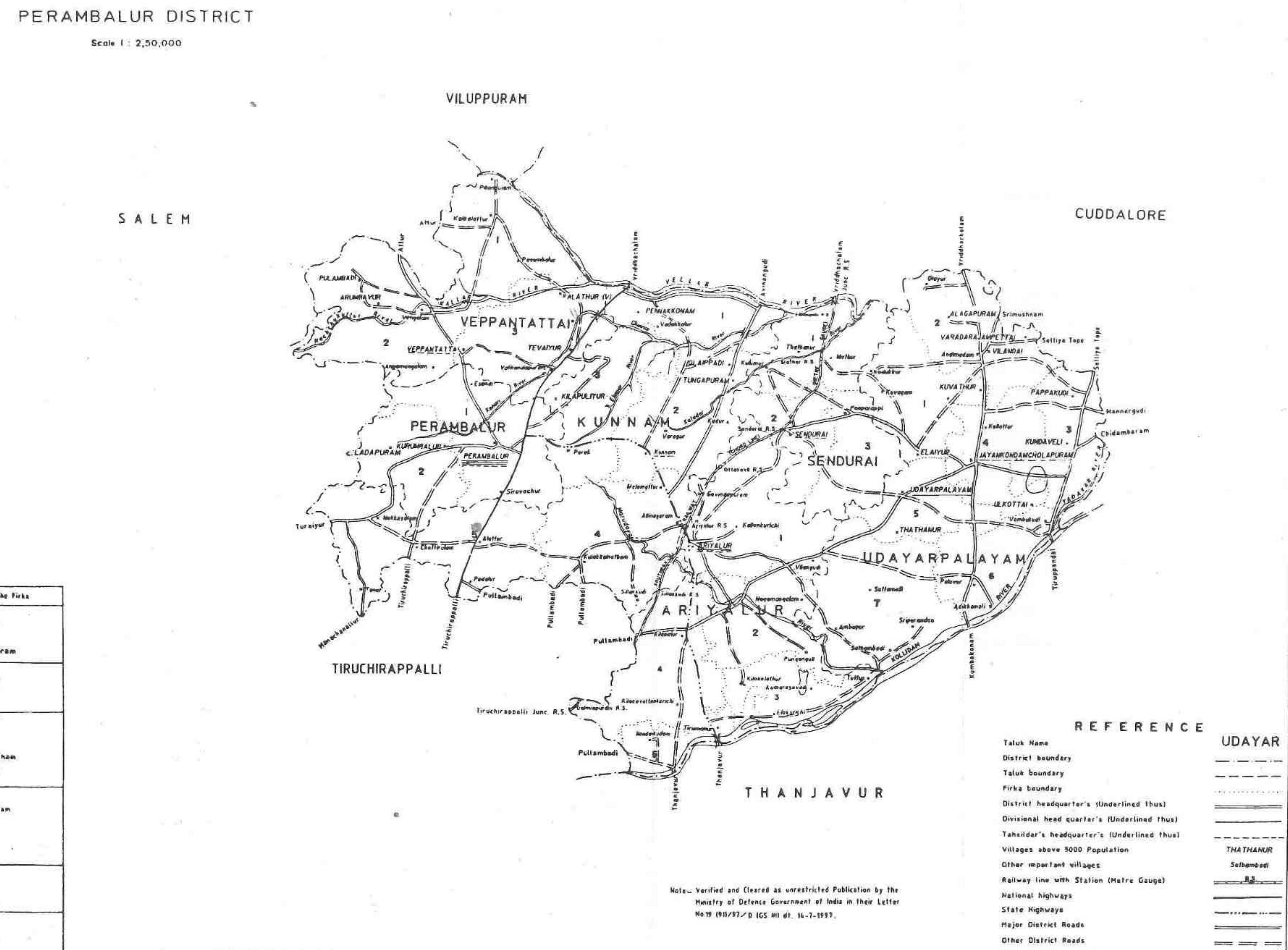


FIGURE 3. LOCATION OF ALATHUR GATE STONE CRUSHING INDUSTRY

FIG. 4 LOCATION MAP OF STONE CRUSHING UNITS AND SOURCE / AIR MONITORING STATIONS (ALATHUR GATE) PERAMBALUR DISTRICT

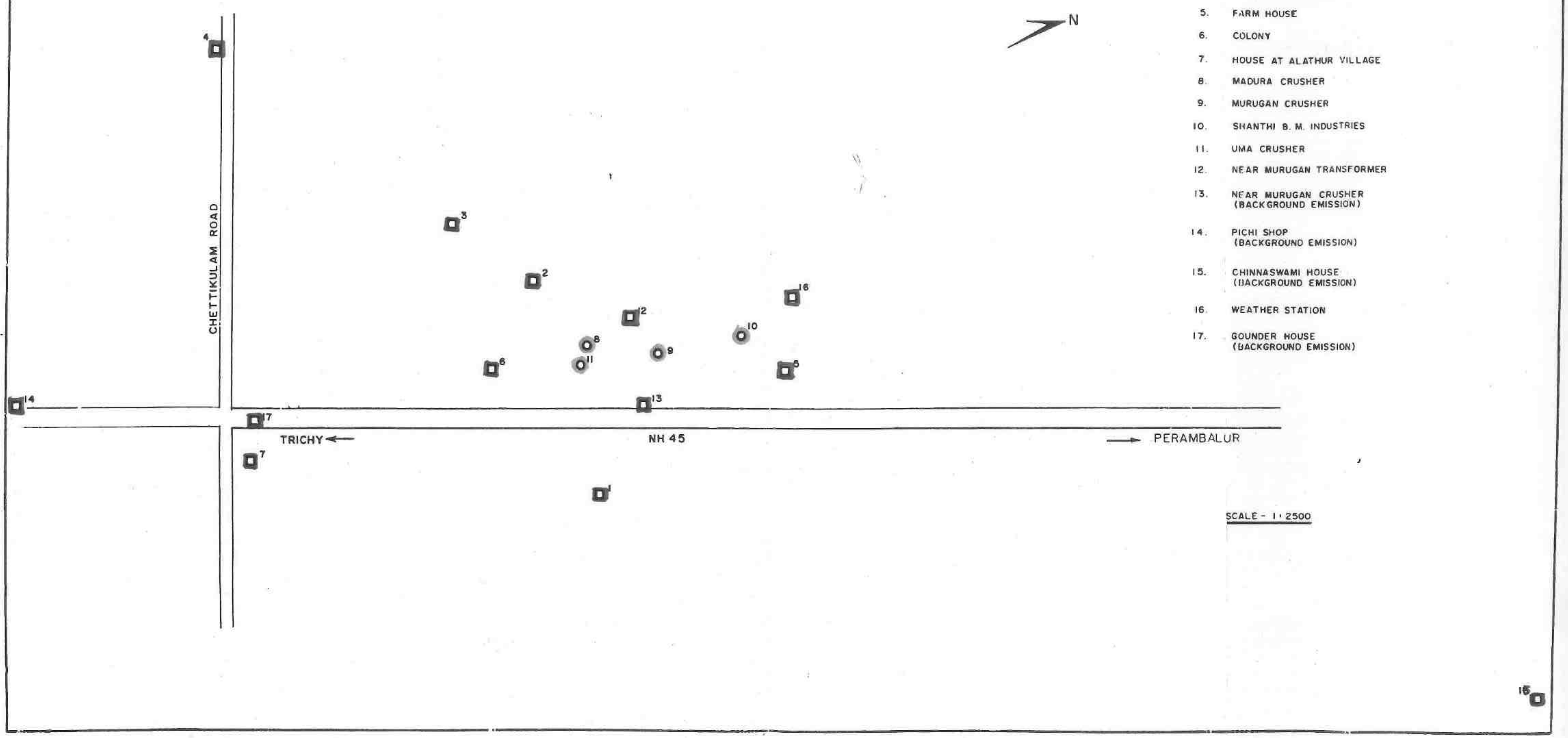


Table 1.1

Distribution of Stone Crushing Units in Tamil Nadu*

Sl. No.	Location	Total No. of Units	Total No.of Units along NH/SH	No.of Units in Industrial area
1.	Tambaram	442	2	6
2.	Hosur	32	7	-
3.	Vellore	68	33	-
4.	Tiruchirapalli	70	32	1
5.	Thanjavur	7	5	-
6.	Cuddalore	99	14	-
7.	Karur	64	6	-
8.	Madurai	44	29	-
9.	Dindigal	29	10	-
10.	Tirunelveli	52	9	9
11.	Tuticorin	7	7	-
12.	Nagarcoil	78	7	-
13.	Coimbatore	48	9	-
14.	Salem	54	6	-
15.	Tiruppur	39	13	-
16.	Erode	58	1	-
	Total	**1191**	**190**	**16**

* Data Supplied by Tamil Nadu Pollution Control Board

Table 1.2

List of Stone Crusher Companies in Operation at Pammal

Sl. No.	Name of the Company	No. of Crushers owned
1.	Rajasthan Trading Corporation	3
2.	K.Rajendran Blue Metal	1
3.	Kumaran Blue Metal	1
4.	K.M.Amirthalingam Blue Metal	2
5.	Pavalavalli Blue Metal	2
6.	Allwin Blue Metal	2
7.	Rajalaxmi Blue Metal	1
8.	Geetha Blue Metal	1
9.	New Kumaran	1
10.	V.S.A. Blue Metal	1
11.	Velco Blue Metal	1
12.	Samco Blue Metal	1
13.	Praveen Blue Metal	2
14.	Kalaiselvi Blue Metal	1
15.	Peter Blue Metal	2
16.	Solai Blue Metal	1
17.	Sri Vigneswara Blue Metal	2
18.	Lakshmi Blue Metal	2
19.	Xavier Blue Metal	2
20.	K.Vellaisamy Blue Metal	1
21.	Balaji Blue Metal	1
22.	Saradha Blue Metal	1
23.	Johnson Blue Metal	1
24.	Amirtham Blue Metal	1
25.	Vinoth Blue Metal	1

Sl. No.	Name of the Company	No. of Crushers owned
26.	Kankaria Trading Corporation	2
27.	Annai Blue Metal	1
28.	Sri Vighnesh Blue Metal	1
29.	Aruna Devi Blue Metal	1
30.	Kavasam Blue Metal	1
31.	V.L.Blue Metal	1
32.	Manickam Blue Metal	1
33.	Susee Blue Metal	1
34.	Senthil Kumaran Blue Metal	1
35.	S.B.Blue Metal	1
36.	A.Shiny Blue Metal	1
37.	Jayanthi Blue Metal	1

Table 1.3

List of Stone Crusher Companies in Operation at Alathur Gate, Perambalur

Sl. No.	Name of the Company	Number of Crushers Owned
1.	Madura Crushers	1
2.	Murugan Crushers	1
3.	Shanthi Blue Metal Industries	1
4.	Uma Crushers	1

Table 1.4

Location of Source and Ambient Air Quality Monitoring Stations at Pammal, Chennai

Sl. No.	Sampling Station	Bearing[1] (deg)	Distance[1] (m)	Sampler Used
1.	Kamarajapuram	15°	390	Hi-Vol Sampler
2.	Open land (Near Kalaiselvi BM)	230°	179	Respirable Particulate Sampler
3.	Open land (Near Vinoth BM)	230°	248	Particulate Sampler
4.	Thiruneermalai	230°	649	Hi-Vol Sampler
5.	Pudhur Shop	310°	174	Respirable Particulate Sampler
6.	Pudhur house	270°	239	Hi-Vol Sampler
7.	Weather station	180°	259	
8.	Open land (near Solai BM)	90°	300	Hi-Vol Sampler
9.	Open land (near KVS BM)	90°	350	Respirable Particulate Sampler
10.	Open land (East of Vigneswara BM)	84°	457	Hi-Vol Sampler
11.	Sankar Nagar	92°	650	Hi-Vol Sampler
12.	Open land (near Rajalakshmi BM)	177°	330	Hi-Vol Sampler
13*.	KVS BM	150°	210	Hi-Vol Sampler
14.	Near Vigneshwara Crusher	115°	235	Hi-Vol Sampler
15*.	KTC	10°	240	Hi-Vol
16*.	Geetha BM	187°	260	Respirable Particulate Sampler

[1] With Respect to Kavasam Blue Metals
* Source Monitoring Stations

Table 1.5

Location of Source and Ambient Air Quality Monitoring Stations at Alathur Gate, Perambalur

Sl. No.	Sampling Location	Bearing[1] (deg)	Distance[1] (m)	Sampler Used
1.	Agricultural land	107°	153	Hi-Vol Sampler
2.	Open land I (Near Madura BM)	225°	100	Respirable Particulate Sampler
3.	Open land II (West of Colony)	225°	200	Hi-Vol Sampler
4.	House on Chettikulam Road	225°	500	Hi-Vol Sampler
5.	Farm House	21°	180	Hi-Vol Sampler
6.	Colony	179°	129	Respirable Particulate Sampler
7.	House at Alathur Village	175°	475	Hi-Vol Sampler
8*.	Madura Crushers	178°	26	Respirable Particulate Sampler
9*.	Murugan Crushers	36.5°	40	Hi-Vol & Respirable Particulate Sampler
10*.	Shanthi B.M. Industries	8°	130	Respirable Particulate Sampler
11.	Near Murugan Transformer	319°	30	Respirable Particulate Sampler
12.	Near Murugan Crushers (Background emission)	77.5°	71	Hi-Vol Sampler
13.	Pichai Shop (Background Emission)	180°	600	Respirable Particulate Sampler
14.	Chinnaswami House (Background Emission)	29.5°	1 km	Respirable Particulate Sampler
15.	Weather Station	358°	187	
16.	Gounder house (Background emission)	177°	400	Hi-Vol Sampler

[1] With Respect to Control Station Near Murugan Crusher
* Source Monitoring Locations

Plate 1 : A View of the Stone Quarry

Plate 2 : Transportation of Quarried Material to Crushers.

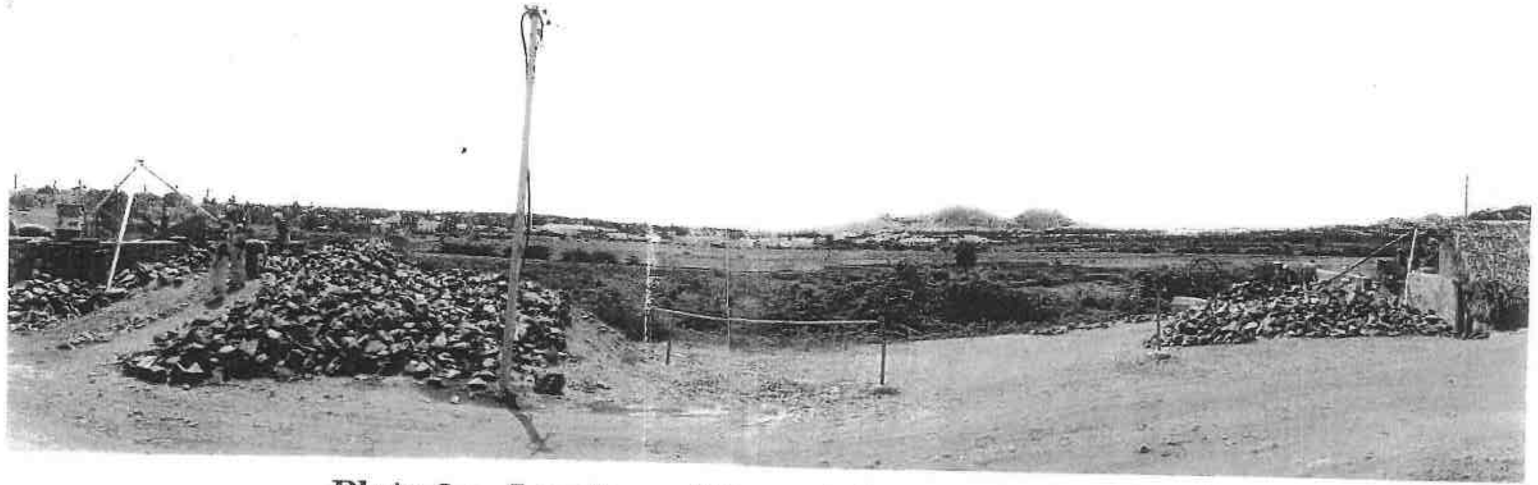


Plate 3 : Loading of Quarried Material into Bunkers.

Plate 4 : A Panoramic View of the Stone Crushers at Pammal

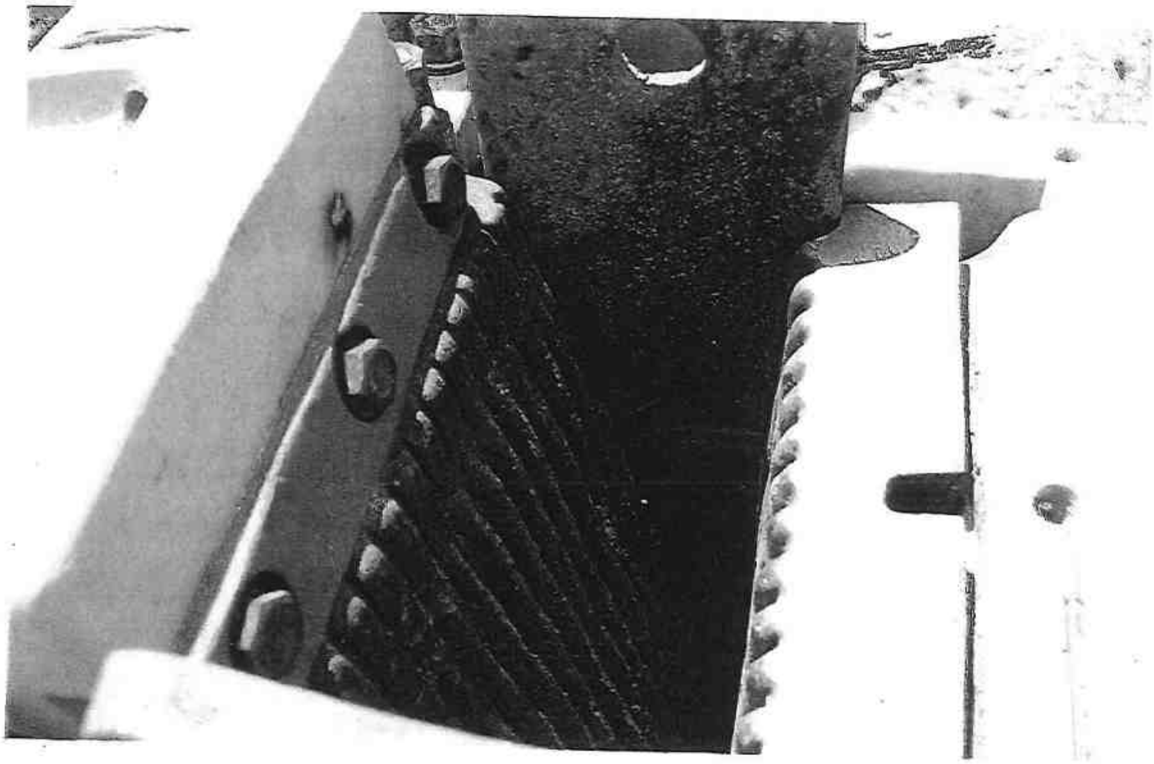


Plate 5 : A View of the Crushing Jaws

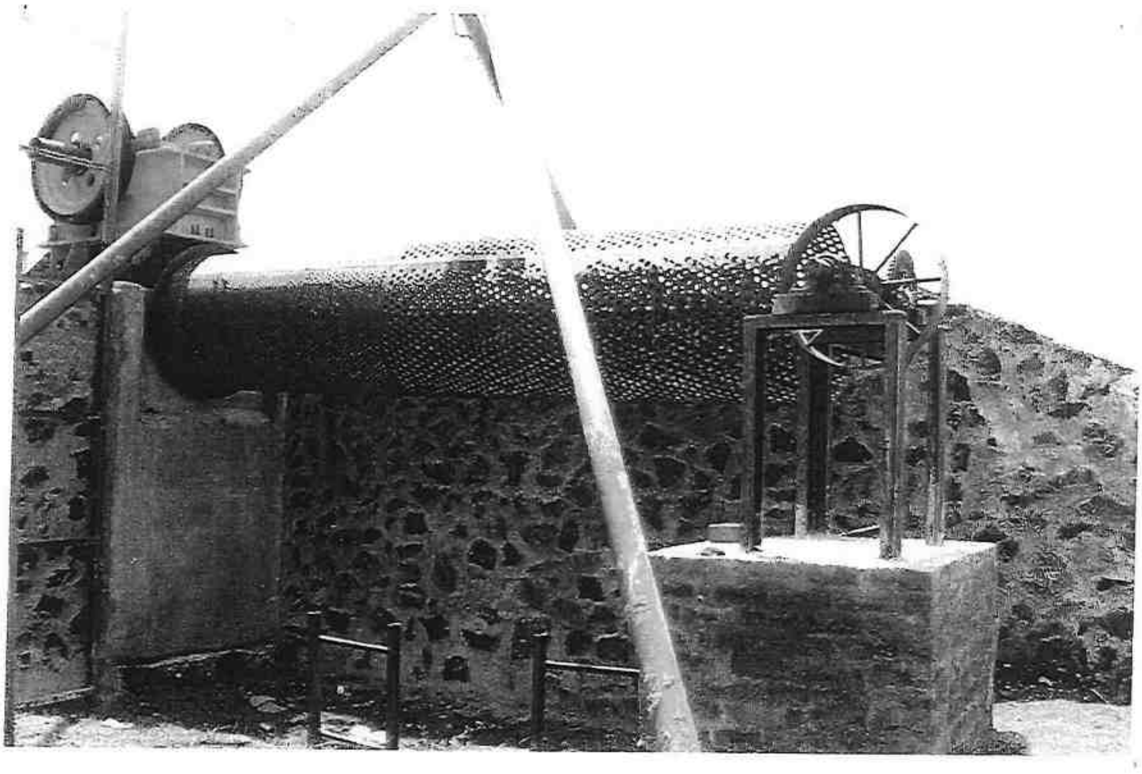


Plate 6 : A View of a Jaw Crusher and Rotary Screen Under Installation

Plate 7 : A Stone Crushing Unit At Pammal

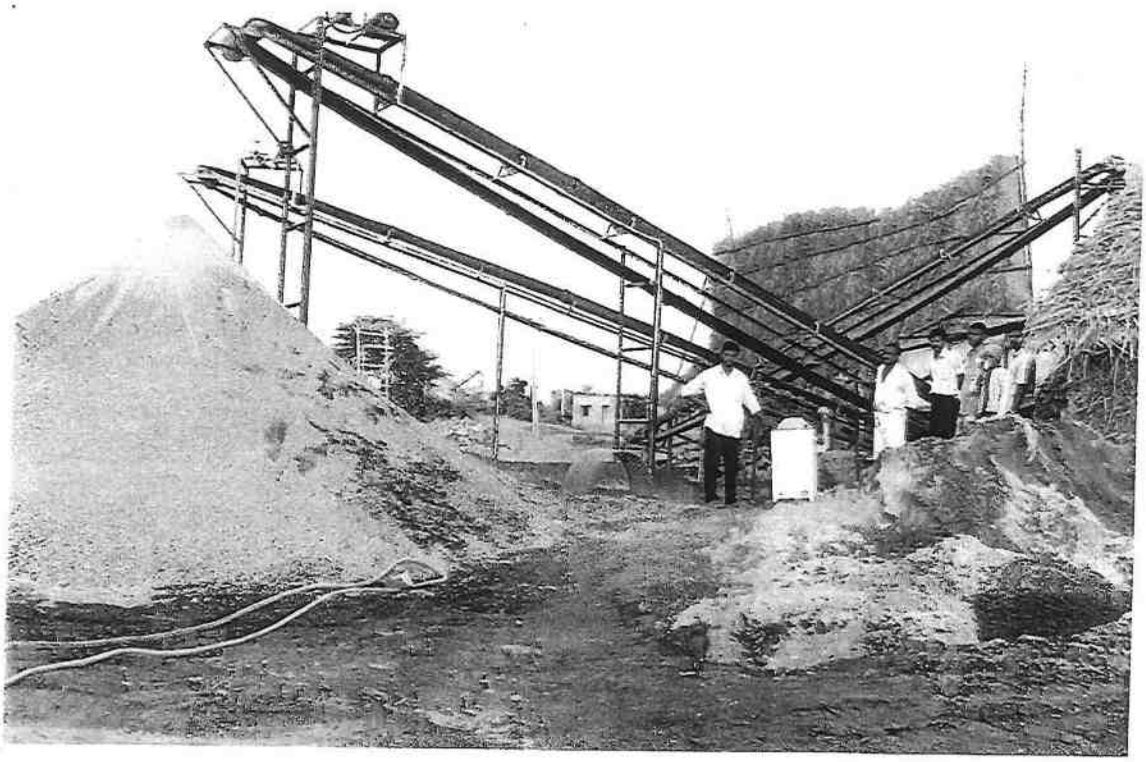


Plate 8 : Source Sampling at a Stone Crushing Unit - Pammal

Plate 9 : Crusher in Operation at Alathur Gate

Plate 10 : Background Emissions Monitoring at Alathur Gate

2.0 Methodology

2.1 Monitoring of Particulate Matter

Monitoring of particulate matter was carried out near the stone crusher units at Pammal (Chennai) and Alathur (Perambalur) For the sampling of particulates, High Volume Samples and Respirable Particulate samplers were used. For the collection of SPM and RPM Glass fibre filter papers (Whatman) were used.

Samplers were run near the crushing units to assess the load of particulate generation at the source and also in the upwind and downwind directions at different distances to assess the distance of travel of the particulates from the stone crushing area. Sampling was done on 8 hourly basis continuously for 24 hours. The collected particulate concentrations were worked out from the difference in weight of filter paper before and after the sample collection. By knowing the average flow measured during the sample collection, the concentration of suspended particulate matter (SPM), respirable particulate matter (RPM) and cyclone dust (particulates above 10 µm size) were calculated and the values were expressed in $\mu g/m^3$ of air.

Sampling schedule was planned to assess the back-ground SPM and RPM concentration at the stone crushing areas by taking the samples when all the crushers were not in operation (N). Samples were also collected to assess the particulate load when all the crushers were in operation (A). Similarly sampling was also carried out when only one of the crusher is in operation to assess the contribution from one individual crusher (O).

2.2 Meteorological Observations

Wind monitor was installed near the crushing area, prior to the schedule of sampling. Wind parameters like wind direction and wind speed were measured prior to the sampling programme, so as to enable to fix the upwind and down wind sampling locations for the Ambient Air Quality Programme with respect to particulate matter. Based on the pilot observations the air sampling network was designed and implemented. Data collection was continued throughout the course of the study. Besides wind direction and wind speed, parameters like temperature and relative humidity were also recorded during the study period.

2.3 Particulate Size Distribution

Besides the SPM and RPM sampling to assess the suspended and respirable ($\leq 10\mu$) particulate matter, the sampled SPM and RPM were also subjected to Laser Diffraction to find out the exact size distribution. This technique gives the real insight into the size distribution of the particulate matter.

3.0 Sampling Programme and Results

3.1 Pammal Stone Crushing Units - Chennai

3.1.1 Particulate Concentration at the Source

Suspended Particulate matter (SPM) sampling was carried out near the crusher source at (1) KTC Blue Metal Company (2) KVS Blue Metal Company and (3)) Kavasam Blue Metal Company during 4.10.97 and 7.10.97. The results are presented in **Table 3.1**. The source SPM Concentration at the KTC Blue Metal Company are 31, 610 and 402 µg/m^3 respectively for minimum, maximum and average concentrations. At the KVS Blue Metal Company the SPM Concentrations were 158, 1485 and 823 µg/m^3 respectively for minimum maximum and average concentration whereas in the Kavasam Blue Metal Company the source SPM Concentrations were 263 µg/m^3 for minimum SPM, 2013 µg/m^3 for maximum SPM and 1229 µg/m^3 for the average SPM Concentration.

Similarly the RPM and cyclone dust concentrations are presented in **Table 3.2**. It is seen that at the Kavasam Blue Metal Company the minimum maximum and average RPM concentration were 189µg/m^3 277 µg/m^3 and 236 µg/m^3, whereas at Geetha Blue Metal Company minimum maximum average RPM concentrations were found to be lower and were 68 µg/m^3, 187 µg/^{3} 112 µg/m^3 respectively.

The minimum, maximum and average cyclone dust concentrations at Kavasam Blue Metal Company were 53 µg/m^3, 2072 µg/m^2 and 1056 µg/m^3. Whereas the cyclone dust concentrations at the Geetha Blue Metal Company were found to be of lower order and the minimum concentration was found to be 31 μg/m^3, maximum observed being 746 μg/m^3 and the average concentration was found to be 334 μg/m^3.

3.1.2 Ambient Respirable Particulate Matter and Cyclone Dust Concentration around the Stone Crushing Units

Ambient RPM sampling was carried out at the different locations, when all the crushers were in operation only one crusher was in operation and no crusher was in operations to find out the RPM contribution from a single crusher and the cluster of crushers and the results are presented in **Table 3.3**. Where no crusher was in operation the minimum, maximum, and average RPM concentrations were found to be 50, 65 and 65 μ/m^3 and this represent the background values at the openland near KVS Blue Metal Company. When one crusher was in operation 37 μg/m^3, 108 μg/m^3 and 68μg/m^3 were the minimum, maximum and average RPM concentrations, whereas a minimum of 59 μg/m^3 maximum of 194 μg/m^3 and average concentration of 138 μg/m^3 were found when all the crushers were in operation. The corresponding cyclone dust concentrations are also presented in **Table 3.3**, which also appears to have the same trend as the RPM Concentration

At Pudhur shop also a similar trend of RPM and cyclone dust concentration was observed as shown in **Table 3.3**. Almost a similar background RPM and cyclone dust concentrations were observed at the ambient air sampling site near the Kavasam Blue Metal Company. Thus it is seen that the RPM concentrations are crossing the TNPCB limits near the Pudhur Shop site when all the crushers were in operation.

3.1.3 Ambient SPM Concentration around the Stone Crushing Units

Ambient SPM sampling was carried out at Pammal stone crushing site in 11 locations at different operating conditions of the crushers and the results are presented in **Table 3.4**. At S.No.1 at Kamarajapuram the background SPM concentrations were high and hence the other results for different operating conditions were also much higher and crossing the TNPCB limits of 200 $\mu g/m^3$. However at S.No.2 near Vigneswara crusher the SPM concentrations were found to be within the standard even when all the crushers were in operation. At Sankar Nagar site also the SPM concentrations were within the TNPCB limits. The SPM results at S.No.4, open land east of Vigneswara Blue Metal Company were also within the prescribed standards.

Near Solai Blue Metal Company open land (S.No.5) all the SPM concentrations were below the standards as seen from **Table 3.4**. At Thiruneermalai site (S.No.6) though the observed maximum concentrations were higher than the standards the average SPM concentrations were within the standards. Almost a similar trend is observed at openland near Rajalakshmi Blue Metal company (S.No.7). At Pudhur house (S.No.8)) the average SPM concentration 211 $\mu g/m^3$ is found to exceed the limit when all the crushers were in operation, whereas in the openland site near Vinodh Blue Metal Company (S.No.9) the average SPM concentration was within the prescribed standards. The results at S.No.10 and 11 represent the back ground SPM concentrations at KVS and Kavasam Blue Metal Companies.

3.1.4 Particulate Contribution from Single and Cluster of Crushers

Table 3.5 presents the incremental contribution of SPM over the background SPM levels, SPM level when one crusher was in operation and all the crushers were in operation. This table is synthesized from the results given in **Table 3.4**. It is seen from **Table 3.5** that at Kamarajapuram all the observed SPM values are higher than all the values presented in the **Table 3.4**. This was because this sampling site being at the entry point of trucks and vans to the stone crushing area and also due to the presence of an isolated crusher nearby. The roads are not pukka and have no pavements. It is also seen from **Table 3.5** that the background SPM concentration varied from 61 μg/m^3 to 276 μg/m^3. The incremental contribution of one crusher to the ambient SPM varied from 10 - 199μg/m^3 and incremental increases in SPM while all the crushers were working varied from 35-409 μg/m^3.

3.2 Alathur Gate Stone Crushing Area, Perambalur

3.2.1 Particulate Concentration of the Source

SPM sampling was carried out at the Sri Murugan crusher area near the source, when all the crushes were is operation. The minimum SPM was 37 μg/m^3 and the maximum was 323 μg/m^3 whereas the average concentration was 127 μg/m^3 as shown in **Table 3.6**. These values are lower than the standards prescribed for residential zone.

Similarly RPM and cyclone dust sampling was carried out at three crushing areas of different crushing units when the conditions of operations were as required for the study. Thus at one unit samples were collected when only one crusher was in operation. Where as at the two other units sampling was carried when all the crusher are in operation. The results for this source sampling are presented is **Table 3.7**. It is seen from the results that all the average RPM concentrations were with in the prescribed limits even at the source. The RPM concentration from a single source was found to be less than the values of multiple crushers. Hence the average cyclone dust concentrations were 125 µg/m^3 for single crusher and 145 and 317 µg/m^3 for multiple crusher.

3.2.2 Ambient RPM and Cyclone Dust Sampling around the Crushers

Ambient respirable particulate matter (RPM)) and cyclone dust sampling was carried out at 5 locations, around the Alathur stone crushing area. The sampling was carried out at different conditions of operation of the crushers and the results are presented in **Table 3.8**. It is seen from the results that at the colony sampling locations. (S.No.1) the observed minimum, maximum and average RPM concentrations were below the TNPCB standards.So also the cyclone dust concentrations were also very low compared to the values observed at Pammal. The background of RPM and cyclone dust were also very low. Similarly the RPM concentration observed at open land, near Madura Blue Metal Company (S.No.2)and near Murugan Transformer (S.No.3) were also within the precribed standards, whereas the results at S.No.4 and 5 represent the background concentrations of RPM and cyclone dust, which are also very much within the standards of TNPCB.

3.2.3 Ambient SPM concentration around the Stone Crushing Units

Ambient SPM Sampling was carried out at Seven locations around the stone crushing area in the dominant downwind direction. The results of the study are presented in **Table 3.9**. Here also the sampling programme was so adjusted that besides the background SPM concentrations, contribution from a single crusher and multiple crushers could be obtained.

It is seen from the results that at the house at Alathur Village the average SPM concentrations were within the standards. It is also seen that the results of S.No.2 to 5 were also within the limits. The results given at S.No.6&7 represent the background concentration nearer to the respective crushing companies. It is seen that the locations near gounder house shows higher concentration of SPM compared to that observed at Murugan Crushers. However it is seen that the observed average SPM concentration varied from 16 $\mu g/m^3$ to 145 $\mu g/m^3$ and that all the concentrations were within the prescribed standards.

This might be due to the better housekeeping at the crushing sites and also due to the well laid pukka roads and parvements in the crushing areas.

3.2.4 Particulate Contribution from Single and Cluster of Crushing Units

Table 3.10 presents the incremental increase of SPM concentrations over the background SPM, when one crusher is in operation and when all the crushers are in operation. These data presented in this table are arrived from the values presented in **Table 3.9**.

Thus it is seen from results in **Table 3.10**, that the background average SPM concentration varied from 16 $\mu g/m^3$ to 53 $\mu g/m^3$. The incremental increase in average SPM when all crushers are in operation varied from 13 $\mu g/m^3$ to 35 $\mu g/m^3$ whereas the incremental increase in SPM due to one crusher in operation varied from 3 $\mu g/m^3$ to 25 $\mu g/m^3$. This it is seen from the results that the incremental increase from one crusher and the cluster of crushers is not very high.

3.3 Climatological Observations

3.3.1 Pammal Stone Crushing Area, Chennai

Meteorological and climatological observations were made at the Pammal stone crushing area from 1.10.97 to 8.10.97. The observations are presented in **Table 3.11**. It is seen from the table that the maximum temperature during the study was 40°C and the minimum was 23°C. The average temperatures during the period varied from 26.8° to 29.9°C. Similarly minimum observed Relative Humidity was 35% and the maximum was 96%, whereas the average Relative Humidity during the study period varied from

65.6% to 82.0%. These climatic conditions were favourable to restrict the dispersion of dust particles to longer distances. The wind rose for Pammal during the study period is shown in Figure 3.1.

The major wind directions during the study period are SW, W and SE with average wind speed in the range of 5-10 km/hr.

3.3.2 Alathur Gate Stone Crushing Area, Perambalur

The climatological data collected at the stone crushing site are presented is **Table 3.12**. The minimum observed temperature was 24°C and the maximum was 28.1°C, where as the average temperature varied between 25.7°C to 28.1°C. The minimum Relative Humidity observed was 40% and the maximum was 86%. The average relative humidity during the study period varied from 70.0% to 81.3%. The wind rose for Alathur Gate during Otober 1997 is shown in Figure 3.2. The predominant wind directions were North East and North with average wind speed in the range of 5-10 km/hr.

3.4 Emission Inventory

Stone crushing units generate dust due to mechanical crushing and screening operations. Granite is used as the raw material for crushing process. The rock in the quarry is loosened by drilling and blasting operations and transported to the stone crushing units (SCU) by lorries. After transfer to the stone crushing unit, the raw material is subjected to various size reduction, size clarification and transfer operations. All these operations emit considerable amount of dust.

In pammal area, there are 48 stone crushing units in the cluster and the total quantity of stone processed is about 1920. For Pammal the measured upwind and downwind SPM concentrations were 126 $\mu g/m^3$ and 1152 $\mu g/m^3$. The estimated emission rate using upwind downwind SPM concentration was 294 kg/day.

In the Alathur gate, Perambalur district, 4 stone crushing units are located in the cluster, namely Uma BM, Madura BM, Murugan BM and Shanthi BM. The total quantity of stone processed is about 280 MT/day. For Alathur Gate the upwind and downwind concentrations are 60 $\mu g/m^3$ and 472 $\mu g/m^3$ respectively. The emission rate works out to be 10 kg/day.

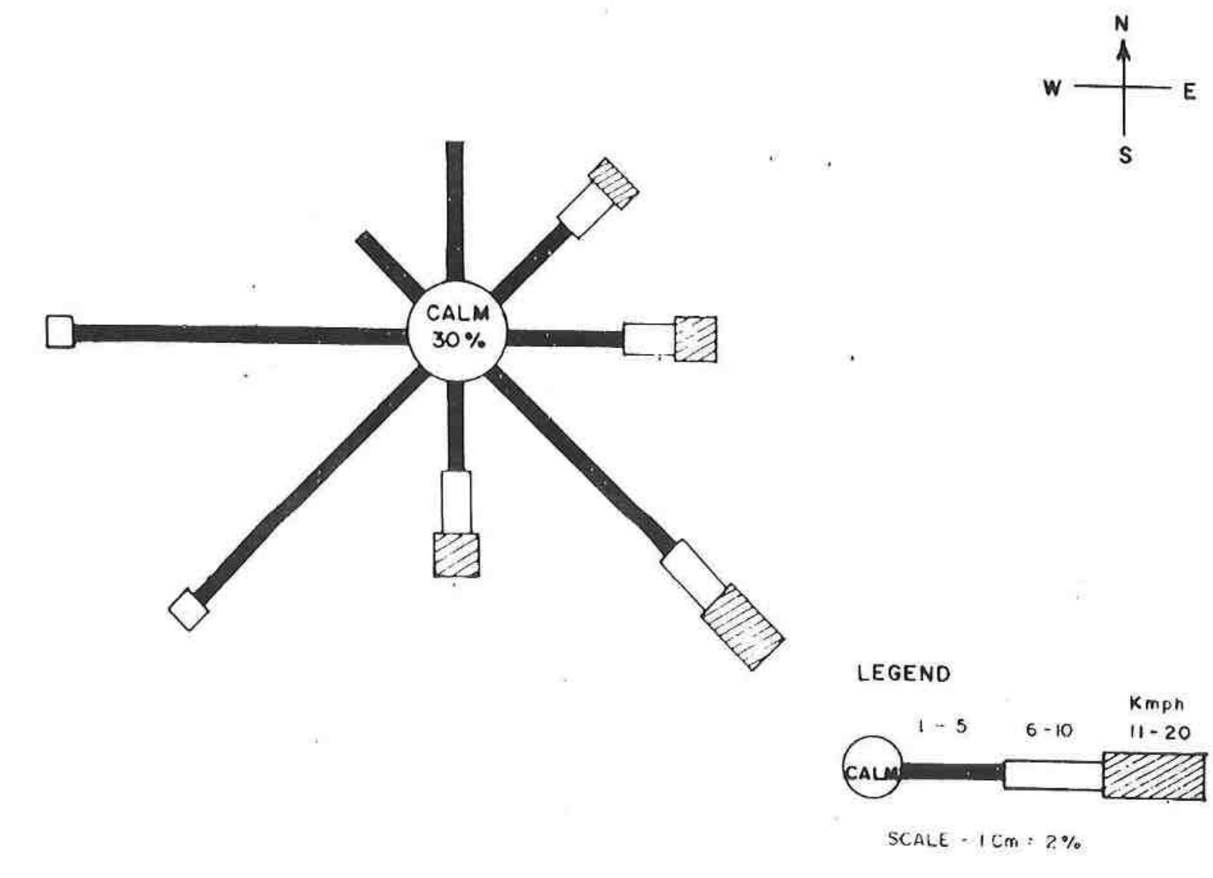


FIG. 3·1 WINDROSE FOR PAMMAL - OCTOBER 1997

Table 3.1

SPM Sampling at Source (Pammal - Chennai)

S. No.	Sampling Location	SPM (µg/m³)		
		Min.[1]	Max.[1]	Average[2]
1.	KTC Blue Metal*	31	610	402
2.	KVS Blue Metal*	158	1485	823
3.	Kavasam Blue Metal*	263	2013	1229

Table 3.2

Respirable Particulate and Cyclone Dust Sampling at Source (Pammal - Chennai)

S. No.	Sampling Location	RPM (µg/m³)			Cyclone Dust (µg/m³)		
		Min.[1]	Max.[1]	Average[2]	Min.[1]	Max.[1]	Average[2]
1.	Kavasam Blue Metal*	189	277	236	53	2072	1056
2.	Geetha Blue Metal*	68	187	112	31	746	334

1 - 8 Hourly Average
2 - 24 Hourly Average
* - Capacity - 40 MT/Day

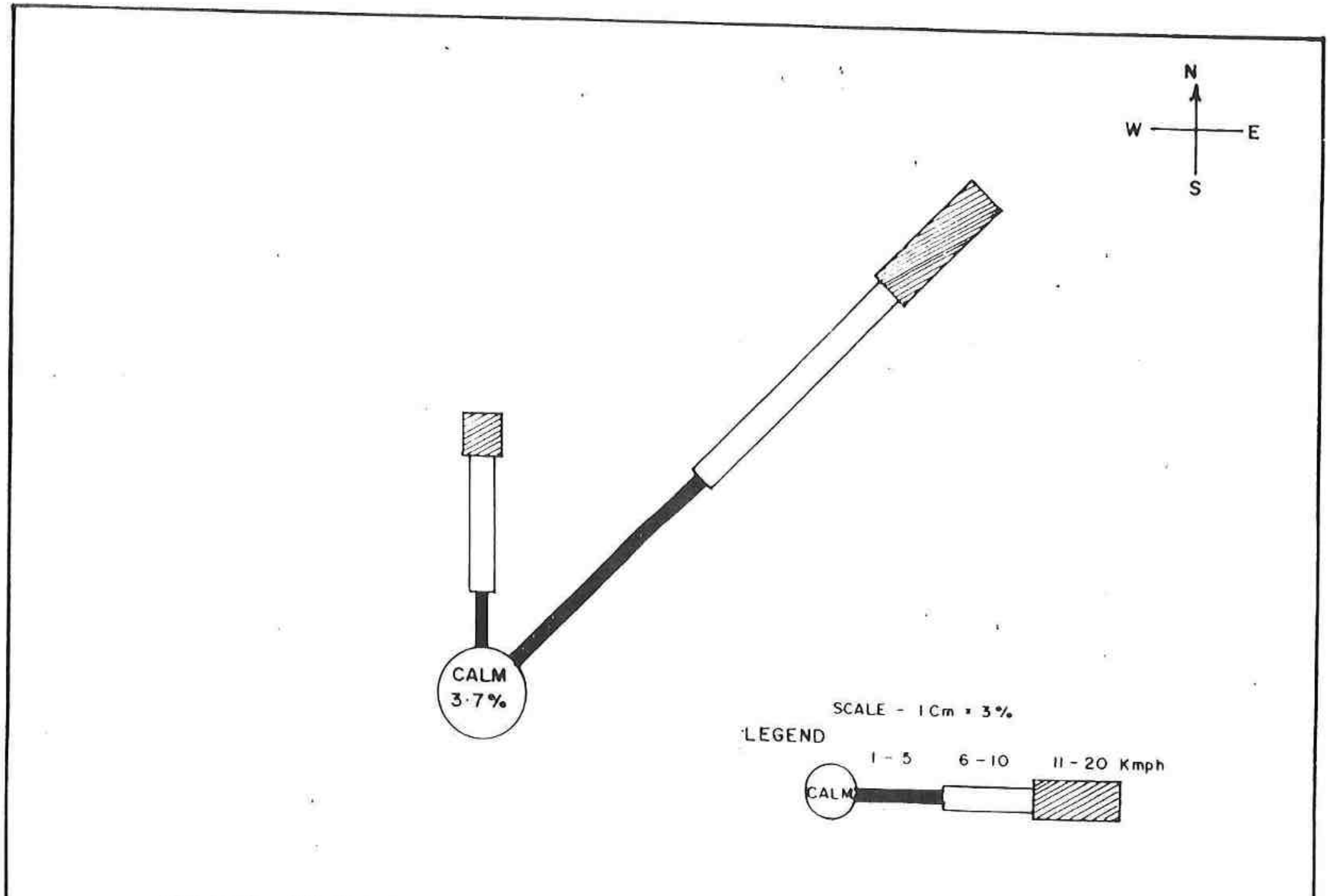


FIG. 3·2 WINDROSE FOR ALATHUR GATE - OCTOBER 1997

Table 3.3

Ambient RPM and Cyclone Dust Sampling around the Crushers (Pammal - Chennai)

S. No.	Sampling Location	Condition While Sampling	RPM (μg/m³)			Cyclone Dust (μg/m³)		
			Min.[1]	Max.[1]	Average[2]	Min.[1]	Max.[1]	Average[2]
1.	Open Land (Near KVS BM)	A	59	194	138	98	255	211
		O	37	108	68	14	140	77
		N	50	65	58	10	96	60
2.	Pudhur Shop	A	70	279	201	22	599	199
		O	77	188	158	6	109	65
		N	15	87	56	5	25	16
3.	Near Kavasam Blue Metal	O	38	55	48	13	72	45

1 - 8 Hourly Average
2 - 24 Hourly Average
A - All crushing units in operation
O - Only one unit is operation
N - No unit in operation

Table 3.4

Ambient SPM Sampling around the Stone Crushing Units (Pammal)

S. No.	Sampling Location	Condition While Sampling	SPM (µg/m³)		
			Min.[1]	Max.[1]	Average[2]
1	Kamarajapuram	A	414	951	685
		O	161	698	475
		N	175	342	276
2	Near Vigneshwara Crusher	A	153	173	163
3	Sankar Nagar	A	66	132	99
		O	78	116	91
		N	56	72	64
4	Open Land (East of Vigneshwara BM)	A	89	214	150
		O	84	104	101
		N	54	100	78
5	Open Land (Near Solai BM)	A	91	193	146
		O	78	128	105
		N	63	99	86
6	Thiruneermalai	A	65	277	192
		O	154	225	190
		N	115	174	140
7	Open Land (Near Rajalakshmi BM)	A	95	250	176
		O	55	177	116
		N	92	121	106
8	Pudhur House	A	113	346	211
		O	117	166	145
		N	60	87	76
9	Open Land (Vinoth BM)	A	58	406	179
		O	109	150	131
		N	52	70	61
10	KVS Blue Metal	N	87	124	109
11	Kavasam Blue Metal	O	121	179	143

1 - 8 Hourly Average
2 - 24 Hourly Average
A - All crushing units in operation
O - Only one unit in operation
N - No unit in operation

Table 3.5

SPM Contribution of One Crushers and Cluster of Crushers (Pammal)

Condition While Working	Kamaraja puram	East			South		Near Rajalakshmi BM	Pudhur House
		Sankar Nagar	East of Vigneshwara BM	Near Solai BM	Thirunee rmalai	Near Vinoth BM		
No Crushing (Background)	276	64	78	86	140	61	106	76
One Crusher Working (Incremental Increase)	199	27	23	19	50	70	10	69
All Crushers Working (Incremental Increase)	409	35	72	60	52	118	70	135

All the values are expressed in $\mu g/m^3$ (24 Hours Average)

Table 3.6

SPM Sampling at the Source
(Alathur, Perambalur)

S. No.	Sampling Location	SPM (µg/m³)		
		Min.[1]	Max.[1]	Average[2]
1.	Sri Murugan Crusher	37	323	127

Table 3.7

Respirable Particulate and Cyclone Dust Sampling at Source
(Alathur, Perambalur)

S. No.	Sampling Location	RPM (µg/m³)			Cyclone Dust (µg/m³)		
		Min.[1]	Max.[1]	Average[2]	Min.[1]	Max.[1]	Average[2]
1.	Shanti Crusher	43	149	95	43	530	317
2.	Sri Murugan Crusher	40	77	58	69	185	125
3.	Madura Crusher	50	99	72	21	251	145

1 - 8 Hourly Average
2 - 24 Hourly Average

Table 3.8

Ambient Respirable Particulate and Cyclone Dust Sampling around Stone Crushers (Alathur, Perambalur)

S. No.	Sampling Location	Conditions While Sampling	RPM ($\mu g/m^3$)			Cyclone Dust ($\mu g/m^3$)		
			Min.[1]	Max.[2]	Average[2]	Min.[1]	Max.[2]	Average[2]
1.	Colony	A	30	77	51	49	77	66
		O	17	73	45	28	85	50
		N	12	25	19	22	50	33
2.	Open Land (Near Madura BM)	A	39	147	78	39	97	61
		O	26	54	38	14	43	29
		N	28	40	34	15	24	19
3.	Near Murugan Transformer	O	28	31	29	14	36	22
4.	Pitchai Shop (Background Concentration)	N	5	34	29	15	59	39
5.	Chinnaswamy (Background Concentration)	N	8	39	36	12	45	30

1 - 8 Hourly Average
2 - 24 Hourly Average

Table 3.9

Ambient SPM Sampling Around the Stone Crushers (Alathur, Perambalur)

S.No.	Sampling Location	Conditions While Sampling	SPM (µg/m³)		
			Min.[1]	Max.[1]	Average[2]
1.	House at Alathur Vilalge	A	55	85	67
		O	50	182	63
		N	5	78	53
2.	Open Land (West of Colony)	A	37	50	43
		O	34	50	41
3.	House on Chettikulam Road	A	42	127	68
		O	28	53	43
		N	5	43	40
4.	Agricultural Land	A	57	45	37
		O	31	35	33
		N	15	33	23
5.	Farm House	A	40	64	51
		O	27	54	41
		N	5	22	16
6.	Near Murugan Crusher	N	15	99	60
7.	Near Gounder House	N	142	149	145

1 - 8 Hourly Average
2 - 24 Hourly Average

Table 3.10

SPM Contribution by a Single Crusher and Cluster of Crushers (Alathur, Perambalur)

S. No.	Condition While Sampling	House at Alathur Village	House on Chettikulam Road	Agricultural Land	Farm House
1.	No Crusher Working	53	40	24	16
2.	All Crushers Working (Incremental Increase)	14	28	13	35
3.	One Crusher Working (Incremental Increase)	10	3	9	25

Values are expressed in µg/m^3 (24 Hours average)

Table 3.11

Temperature and Humidity during the Study Period - Pammal

Date	Temperature (°C)			Relative Humidity (%)		
	Min.	Max.	Average	Min.	Max.	Average
1.10.97	25	39	29.1	35	96	82.0
2.10.97	26	37	28.4	50	95	82.0
3.10.97	24	38	29.9	40	95	73.7
4.10.97	24	40	30.3	35	93	65.6
5.10.97	24	37	26.8	45	90	70.8
6.10.97	24	35	27.7	50	91	72.6
7.10.97	24	37	29.2	50	90	66.1
8.10.97	23	36	29.0	45	95	69.8

Table 3.12

Temperature and Humidity during the Study Period - Alathur, Perambalur

Date	Temperature (°C)			Relative Humidity (%)		
	Min.	Max.	Average	Min.	Max.	Average
16.10.97	25.0	35.0	28.1	40	84	70.6
17.10.97	25.0	34.0	27.5	56	84	74.8
18.10.97	24.0	31.0	27.0	62	86	81.3
19.10.97	25.0	36.0	25.7	51	86	70.0

4. Particle Size Analysis

4.1 Preamble

The size distribution of particulate matter in air determines its potential for adverse effects on health and visibility. The aerodynamic size of the particle dictates whether it falls rapidly to the ground or remains suspended to enter the human respiratory system. Again depending upon size and chemical nature, the particle may be filtered out in the upper nasal system, settle in the tracheo bronchial system, penetrate into the alveoli or remain suspended to be expired.

Atmospheric particle size distribution shows multimodal pattern due in a large part to the mechanism of their generation. The modes are usually grouped into two broad classifications for air pollution purposes fine and coarse. Fine particles are considered to be those smaller, 2 to 3 µm in diameter. The fine (respirable) particles can penetrate into the pulmonary region of the respiratory system. Coarse particles are principally formed by mechanical, grinding or other dispersive forces. Their size ranges from approximately 1 to more than 100 µm in diameter, depending upon the dispersive forces and atmospheric conditions. The fine stage has an upper cut off particles point of 2.5 µm, the coarse (inhalable) stage has an upper cut-off particles point of either 10 or 15 µm depending upon design. Present tendencies are to standardize on the 10 µm cut-off point as the respirable particulates.

Dust particles emitted from a given source are dispersed into the atmosphere where the small particles stay in suspension for a long time while the larger particles settle under gravity at near distance from the source. Particles larger than 30 µm are usually deposited within short distance from the source and small particle of size in the range 15-20 µm stays longer time in the atmosphere. Particle size analysis plays an important role in the characterisation of dust emission from stone crushing operation and estimation of percentage of air borne particle which is transported over longer distance from the source causing environmental health effects. The most important particle properties related to atmospheric transport are size, shape and size distribution. Physical properties such as density and moisture also play an important role in the transport.

Emphasis is usually given to dust emission in the inhalable size range (<15 µm). Fine inhalable dust particles ≤ 2.5 µm enter human respiratory system causing more damage than that of coarse inhalable particles of the size range 2.5 to 15 µm. Hence it is important to carry out particle size analysis for the size distribution of suspended particulates.

Particle size analysis was carried out by using Shimadzu Laser Diffraction Particle Size Analyser SALD-1100. Of the many particle size measuring methods, laser diffraction technique has distinctive features such as simplified operation, excellent repeatability and short measuring time. The result of measurements is printed out automatically within 3 minutes after the measurement is started.

4.2 Particle Size Analysis at Source

4.2.1 Pammal, Chennai

There are 48 stone Crushing units located in the Pammal study area of which, 3 Stone Crushing units were identified for particle size analysis, viz., KVS BM, Kavasam BM, KTC BM as shown in **Fig.2**. The results of the particle size analysis are presented in the form of cumulative distribution graph and differential distribution Graph (Histogram). The cumulative distribution graph shows percentage of particles less than the particle size of interest (**Figs.4.1, 4.3, 4.5 & 4.7**). The different particle size percentage fractions are shown in the Histogram. The particle size distribution data is given in the **Tables 4.1-4.6** indicating percentage of particles in the specified range and at desired (selected) diameters.

From the analysis at three representative sources, it has been found that inhalable/respirable particulate matter which is defined as PM_{10} with aerodynamic diameter not greater than 10μm is 37.7%, 48.2%, 53.9% at KVS BM, Kavasam BM and KTC BM respectively, with an average of 46.6%. The suspended particulate matter which is defined as aerodynamic diameter not greater than 30μm is 85.1, 88.4, 92.5% respectively at the above 3 locations with average 88.7% indicating that the dust emissions are finer in nature. The settleable particulate matter which is greater than 30μm is constituting about 14.9, 11.6, 7.5% at these locations with average value 11.3%.

Fraction of Fine and Coarse particles at Source (%)

S.No.	Sampling Location	≤ PM10	≤ PM15	≥ P30
1.	KVS BM	37.7	52.7	14.9
2.	Kavasan BM	48.2	61.5	11.6
3.	KTC BM	53.9	67.8	7.5
	Average	**46.6**	**60.7**	**11.3**

The differential distribution Graphs **(Figs.4.2, 4.4 & 4.6)** show that maximum percentage of particles are occurring in the ranges 1-5μm, 3-5μm, 8-10μm with peak occurring in the range 15-20μm.

4.2.2 Alathur Gate, Perambalur District

There are 4 stone crushing units viz, Shanthi BM, Murugan BM, Madura BM and Uma BM located in the cluster, out of which particle size analysis is carried out at Murugan BM. The analysis results are plotted in the form of cumulative distribution graph and differential distribution graph as shown in **Figs. 4.7 & 4.8**. The percentage of desired particle size and selected range are also given in **Table 4.4.**

The results indicate that PM_{10}, PM_{15}, and PM_{30} fractions are 64%, 76.9% and 95.4% respectively indicating that stone dust is finer in nature. The differential distribution graph shows that maximum percentage of particles are in the range of 1-2μm, 8-10μm, 15-20μm with peak occurring at 3-5 μm range showing maximum percentage of particles are in the respirable range.

4.3 Particle Size Analysis in the Ambient Air

4.3.1 Health Effects

An ambient air quality standard based merely on the mass concentration of total suspended particulate material (TSP) is rather poorly related to the actual pollutant burden on exposed individuals. The human respiratory system can remove large particles, and air quality standards based on TSP may not provide adequate protection. Standards based solely on the total mass of particulate do not reflect the potentially greater health impact of specific particulate species or size ranges, especially fine particulate matter. The potential for health impact for such classes of particulate matter can be disproportionately large relative to its fractional part of the total mass of suspended particulate material. The fine particulate fraction (2.5 µm aerodynamic diameter) accounts for a substantial impact on human health and the quality of the human environment.

The human respiratory system acts as an highly effective filter for coarse particles, removing a large percentage of those inhaled particles of an aerodynamic diameter greater than 2.5µm. Those smaller particles are capable of penetrating deep into the lungs, where their physical presence can increase airway resistance and susceptibility to infection, and reduce lung function.

The respiratory tract is a highly effective particle filter for particles larger than 2.5 µm. Particles deposited in the nose and throat are removed via the mucociliary system. This mechanism is not available for removing particles deposited deep within the lungs. Particles deposited in the alveoli may persist for time periods as long as a year. In the alveolar region, a significant fraction of the particles may enter the lung interstices. Particles can then be transported into the lymphatic system or circulatory system to other organs of the body. Material may reach and accumulate in any target organ or may be excreted via natural pathways.

The deposition of irritant particulate matter inhaled into the respiratory tract can cause acute symptoms such as cough, bronchial constriction and over - secretion of mucus. Chronic exposures may result in the impairment of lung elasticity and gaseous exchange efficiency and cause an increased susceptibility to infections. In extreme cases, lung tissue may become fibrotic.

4.3.2 Pammal, Chennai

Particle size analysis was carried to quantify the fraction of particles transported to the receiver and related human health problems. The results of the analysis are shown in **Figs. 4.9 & 4.10** and **Table 4.5**. Based on particle size analysis the estimated $PM_{2.5}$ concentration from sources and ambient air are presented in Table 4.7. It is seen from the results that the ambient $PM_{2.5}$ particulate concentration was 34 $\mu g/m^3$ at Pammal and 11 $\mu g/m^3$ at Alathur site. The fine inviable/respirable particle which is defined as $PM_{2.5}$ with an aerodynamic diameter not greater than 2.5μm is about 22.6% showing higher percentage than that of source $PM_{2.5}$ fractions (**Table 4.7**).

The coarse inhalable/respirable particles PM_{10} and PM_{15} are 66.3% and 78.8% respectively, indicating the presence of higher percentage of respirable particulate matter in the air. Settleable particulate matter greater than >30µm are only 4.8% which is marginal, indicating deposition/settling of these fractions nearby sources. The differential distribution graph shows that maximum of particles are in the range of 1-2, 3-5, 8-10 µm and with a peak value occurring in the range 3-5µm.

4.3.3 Alathur Gate, Perambalur District

The results of the analysis are presented in **Figs 4.11 & 4.12** and **Table 4.6.** The fine inhalable particle $PM_{2.5}$ is about 25% with coarser respirable particles PM_{10} and PM_{15} showing higher fraction of 60% and 69.9% respectively. Settleable particulate matter (≥30µm) is only 9.8% which is marginal indicating the presence of more fine respirable particles in the ambient air away from source and settleability of larger size particles near by the source.

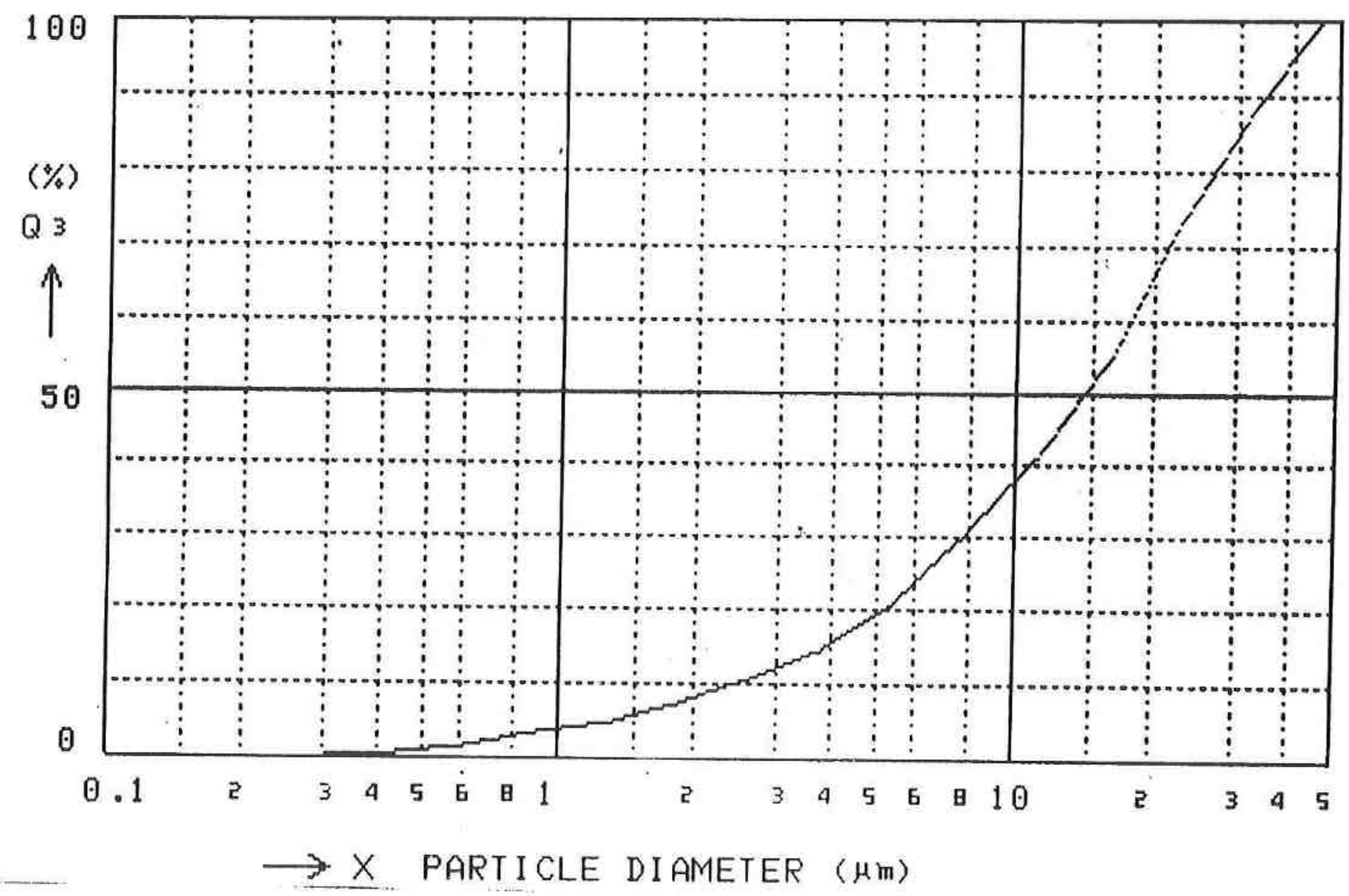


Fig. 4.1 Cumulative Distribution Graph : Source
(KVS - Pammal)

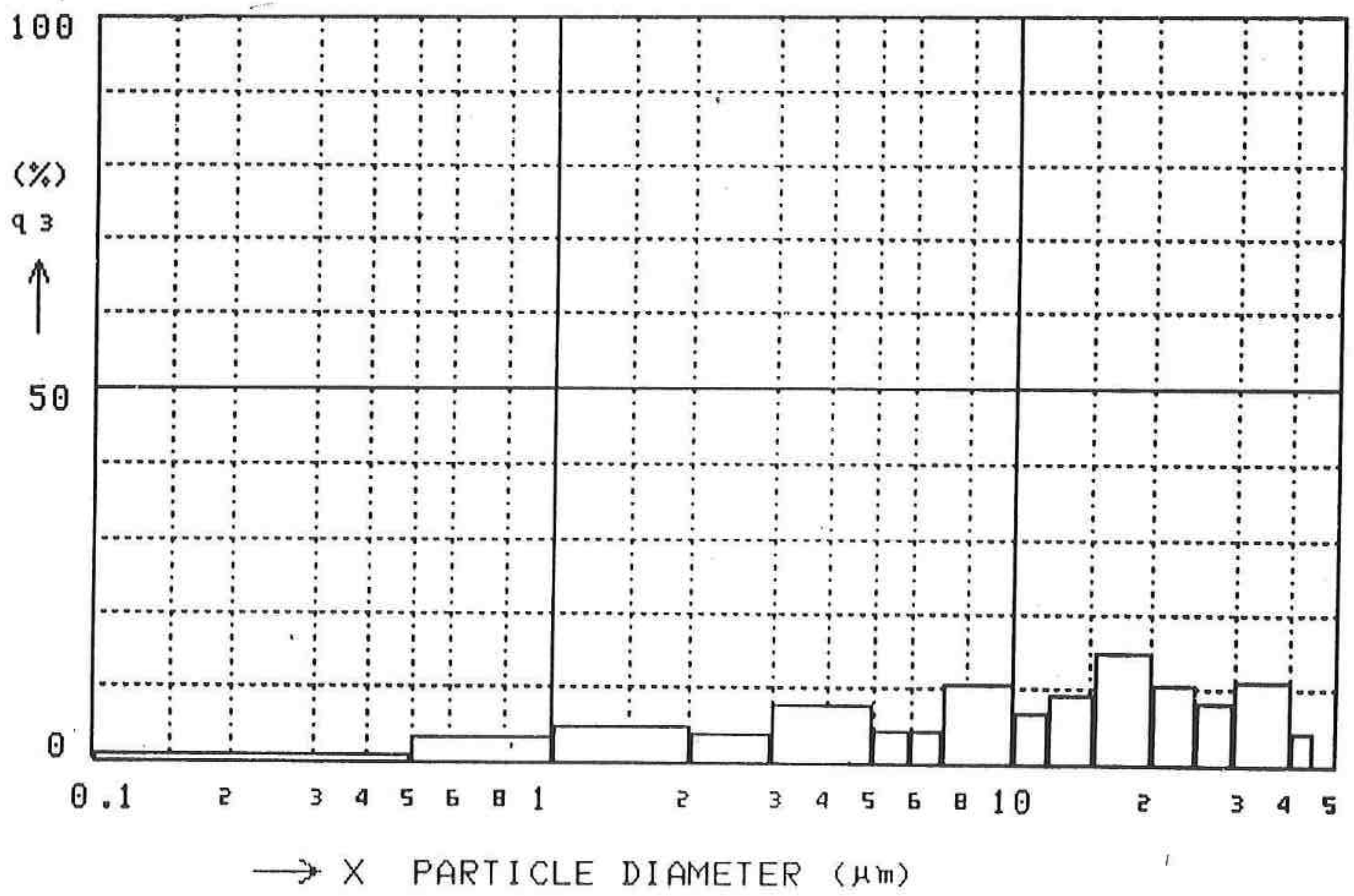


Fig. 4.2 Differential Distribution Graph : Source
(KVS - Pammal)

Table 4.1
Particle Size Distribution Data : Source (KVS - Pammal)

Sl.No.	Dia. (μm)	Diff. (%)	Cum. (%)	Dia. (μm)	Cum. (%)
1.	45		100.0	34.15	90
2.	40	4.3	95.7	29.92	85
3.	**30**	**10.6**	**85.1**	**26.56**	**80**
4.	25	7.7	77.5	23.58	75
5.	20	10.4	67.0	21.15	70
6.	**15**	**14.4**	**52.7**	**19.25**	**65**
7.	12	8.8	43.9	17.52	60
8.	**10**	**6.3**	**37.7**	**15.92**	**55**
9.	7	10.3	27.3	14.01	50
10.	6	3.9	23.4	12.34	45
11.	5	4.2	19.2	10.81	40
12.	3	7.4	11.8	9.15	35
13.	2	3.8	8.0	7.73	30
14.	1	4.5	3.6	5.23	20
15.	0.5	3.1	0.5	2.51	10
16.	0.1	0.5	0	1.36	5

Sl.No.	Dia. (μm)	Diff. (%)	Cum. (%)
1.	45.00 - 31.00	13.5	100.0
2.	31.00 - 22.00	14.4	86.5
3.	22.00 - 16.00	16.9	72.1
4.	16.00 - 11.00	14.7	55.2
5.	11.00 - 7.50	11.4	40.5
6.	7.50 - 5.30	8.8	29.1
7.	5.30 - 3.70	6.2	20.2
8.	3.70 - 2.60	3.7	14.0
9.	2.60 - 1.80	3.2	10.3
10.	1.80 - 1.30	2.5	7.1
11.	1.30 - 0.88	1.7	4.7
12.	0.88 - 0.60	2.0	3.0
13.	0.60 - 0.43	0.9	1.0
14.	0.43 - 0.30	0.1	0
15.	0.30 - 0.17	0	0
16.	0.17 - 0.10	0	0
17.	0.10		

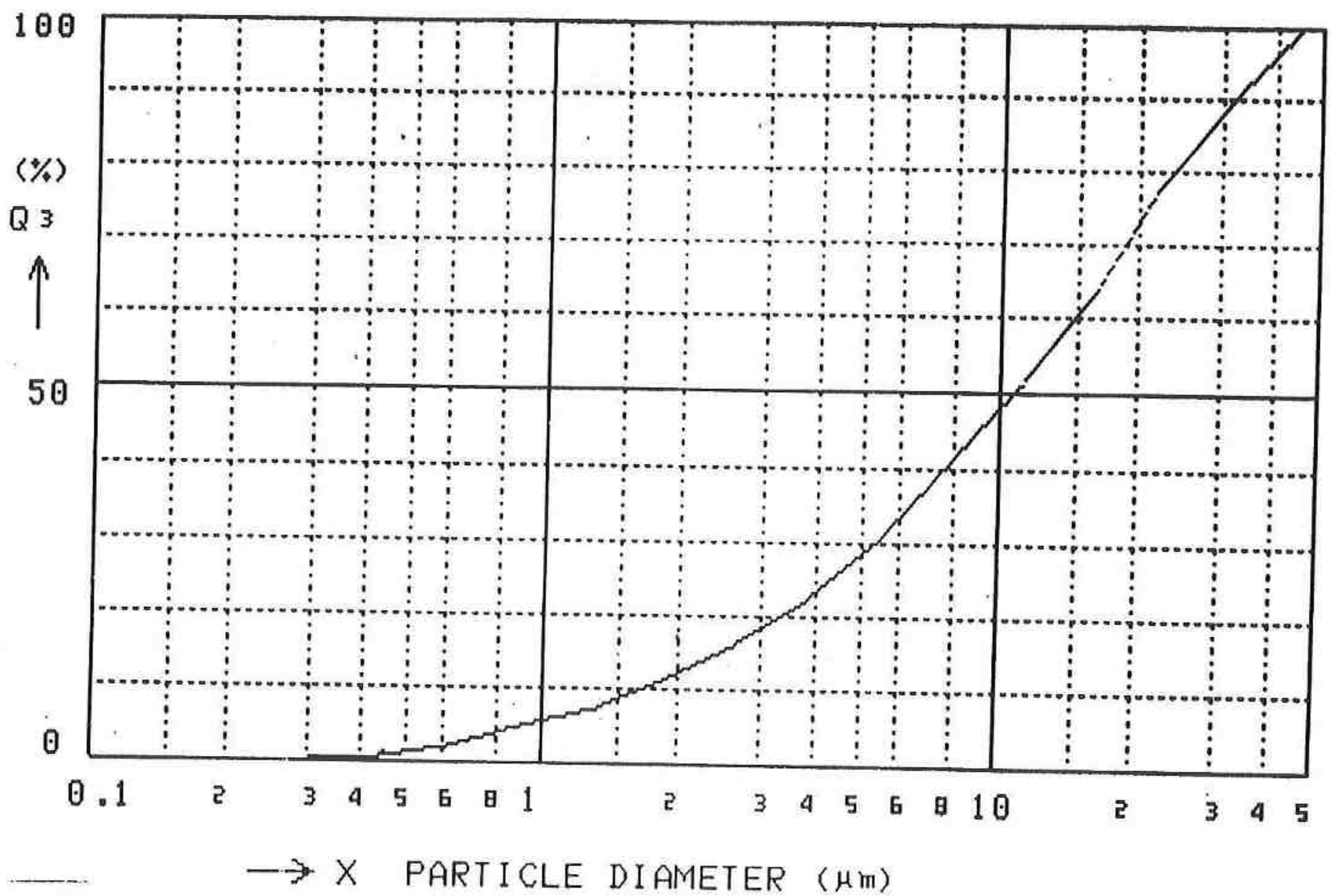


Fig. 4.3 Cumulative Distribution Graph : Source (Kavasam - Pammal)

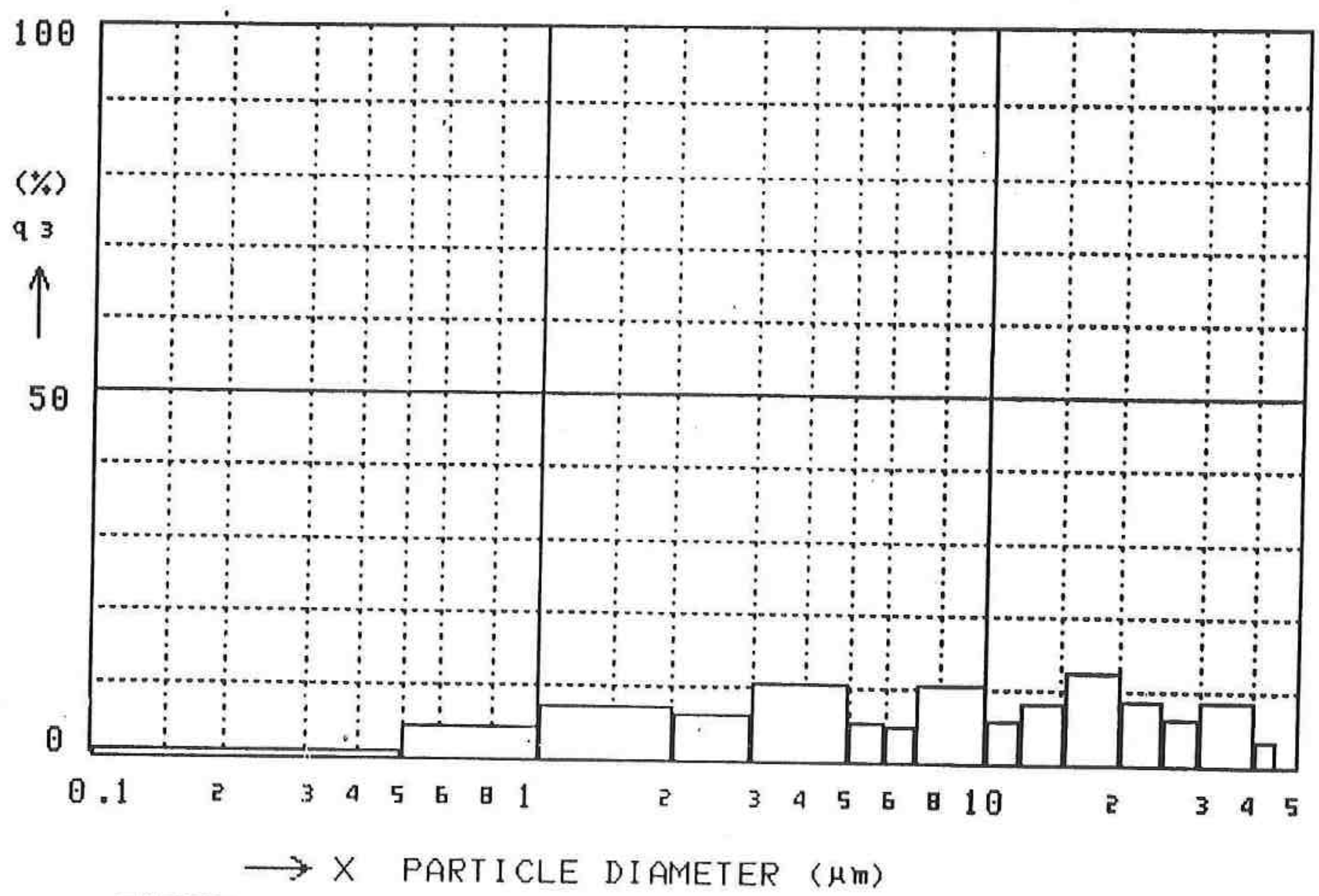


Fig. 4.4 Differential Distribution Graph : Source (Kavasam - Pammal)

Table 4.2

Particle Size Distribution Data : Source (Kavasam - Pammal)

Sl.No.	Dia. (µm)	Diff.(%)	Cum. (%)	Dia. (µm)	Cum. (%)
1.	45		100.0	31.60	90
2.	40	3.3	96.7	27.16	85
3.	30	8.3	88.4	23.41	80
4.	25	6.1	82.2	20.61	75
5.	20	8.5	73.7	18.42	70
6.	15	12.1	61.5	16.46	65
7.	12	7.6	53.9	14.34	60
8.	10	5.7	48.2	12.38	55
9.	7	10.3	37.9	10.64	50
10.	6	4.5	33.4	8.94	45
11.	5	5.0	28.4	7.51	40
12.	3	10.4	18.0	6.34	35
13.	2	6.0	12.0	5.34	30
14.	1	7.0	5.1	3.39	20
15.	0.5	4.3	0.8	1.71	10
16.	0.1	0.8	0	0.99	5

Sl.No.	Dia. (µm)			Diff. (%)	Cum. (%)
1.	45.00	-	31.00	10.5	100.0
2.	31.00	-	22.00	11.6	89.5
3.	22.00	-	16.00	14.1	77.9
4.	16.00	-	11.00	12.8	63.8
5.	11.00	-	7.50	11.0	51.0
6.	7.50	-	5.30	10.2	40.0
7.	5.30	-	3.70	8.3	29.8
8.	3.70	-	2.60	5.7	21.4
9.	2.60	-	1.80	5.1	15.7
10.	1.80	-	1.30	3.9	10.6
11.	1.30	-	0.88	2.4	6.7
12.	0.88	-	0.60	2.7	4.3
13.	0.60	-	0.43	1.4	1.6
14.	0.43	-	0.30	0.2	0.2
15.	0.30	-	0.17	0	0
16.	0.17	-	0.10	0	0
17.	0.10				0

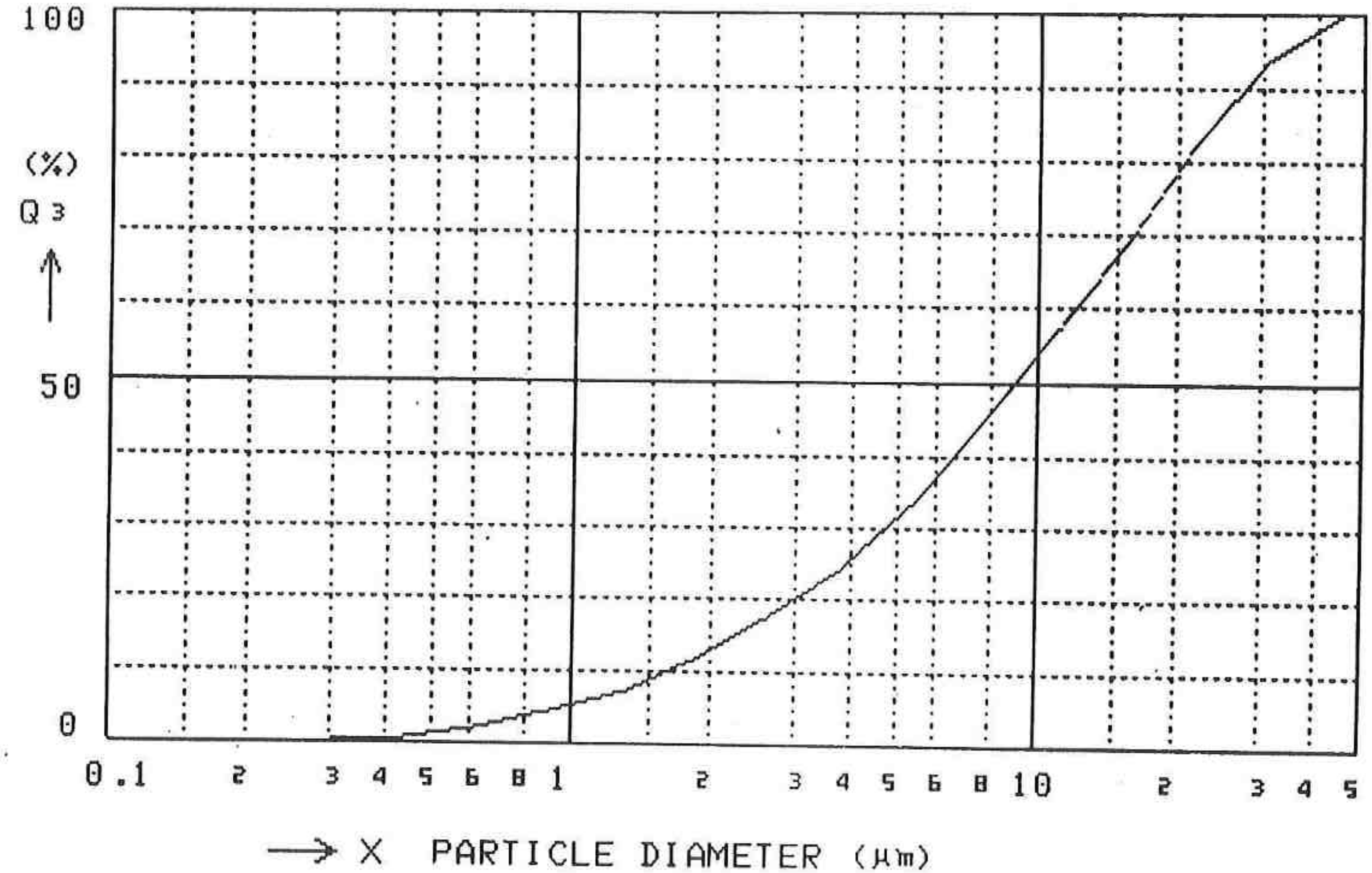


Fig. 4.5 Cumulative Distribution Graph : Source (KTC - Pammal)

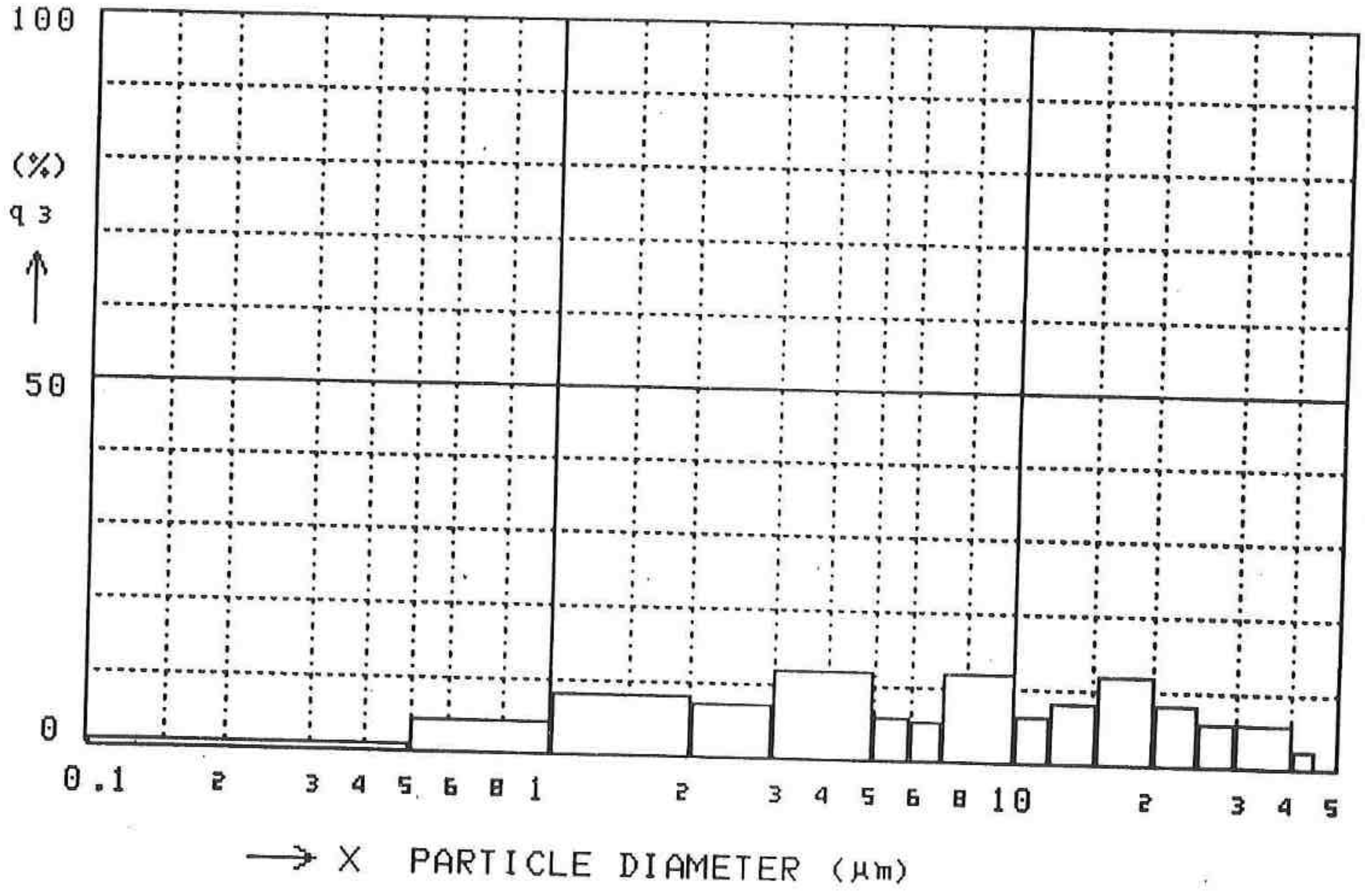


Fig. 4.6 Differential Distribution Graph : Source (KTC - Pammal)

Table 4.3
Particle Size Distribution Data : Source (KTC - Pammal)

Sl.No.	Dia. (µm)	Dif.	Cum.	Dia. (µm)	Cum.
1.	45		100.0	27.55	90
2.	40	2.0	98.0	23.29	85
3.	30	5.4	92.5	20.32	80
4.	25	5.4	87.1	18.02	75
5.	20	7.8	79.3	15.98	70
6.	15	11.5	67.8	13.84	65
7.	12	7.8	60.0	12.00	60
8.	10	6.1	53.9	10.35	55
9.	7	11.6	42.3	8.86	50
10.	6	5.1	37.2	7.59	45
11.	5	5.7	31.6	6.52	40
12.	3	11.9	19.7	5.61	35
13.	2	6.9	12.8	4.71	30
14.	1	7.8	5.0	3.05	20
15.	0.5	4.1	0.9	1.66	10
16.	0.1	0.9	0	1.00	5

Sl.No.	Dia. (µm)	Diff.(%)	Cum.(%)
1.	45.00 - 31.00	6.5	100.0
2.	31.00 - 22.00	10.2	93.5
3.	22.00 - 16.00	13.2	83.3
4.	16.00 - 11.00	13.1	70.1
5.	11.00 - 7.50	12.3	57.0
6.	7.50 - 5.30	11.5	44.6
7.	5.30 - 3.70	9.5	33.1
8.	3.70 - 2.60	6.7	23.6
9.	2.60 - 1.80	5.9	17.0
10.	1.80 - 1.30	4.3	11.1
11.	1.30 - 0.88	2.6	6.8
12.	0.88 - 0.60	2.4	4.2
13.	0.60 - 0.43	1.5	1.8
14.	0.43 - 0.30	0.3	0.3
15.	0.30 - 0.17	0	0
16.	0.17 - 0.10	0	0
17.	0.10		0

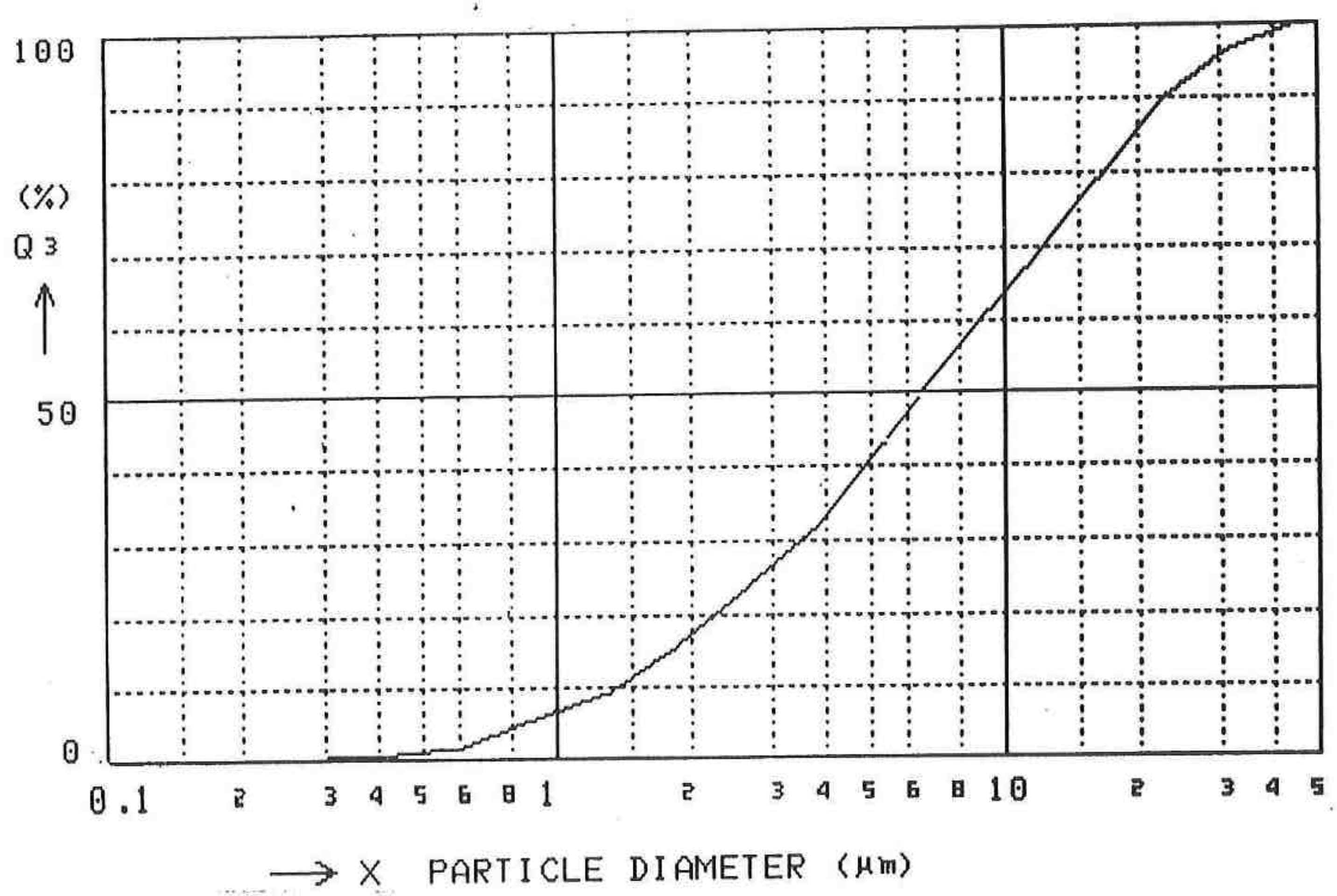


Fig. 4.7 Cumulative Distribution Graph : Source
(Murugan BM - Alathur Gate)

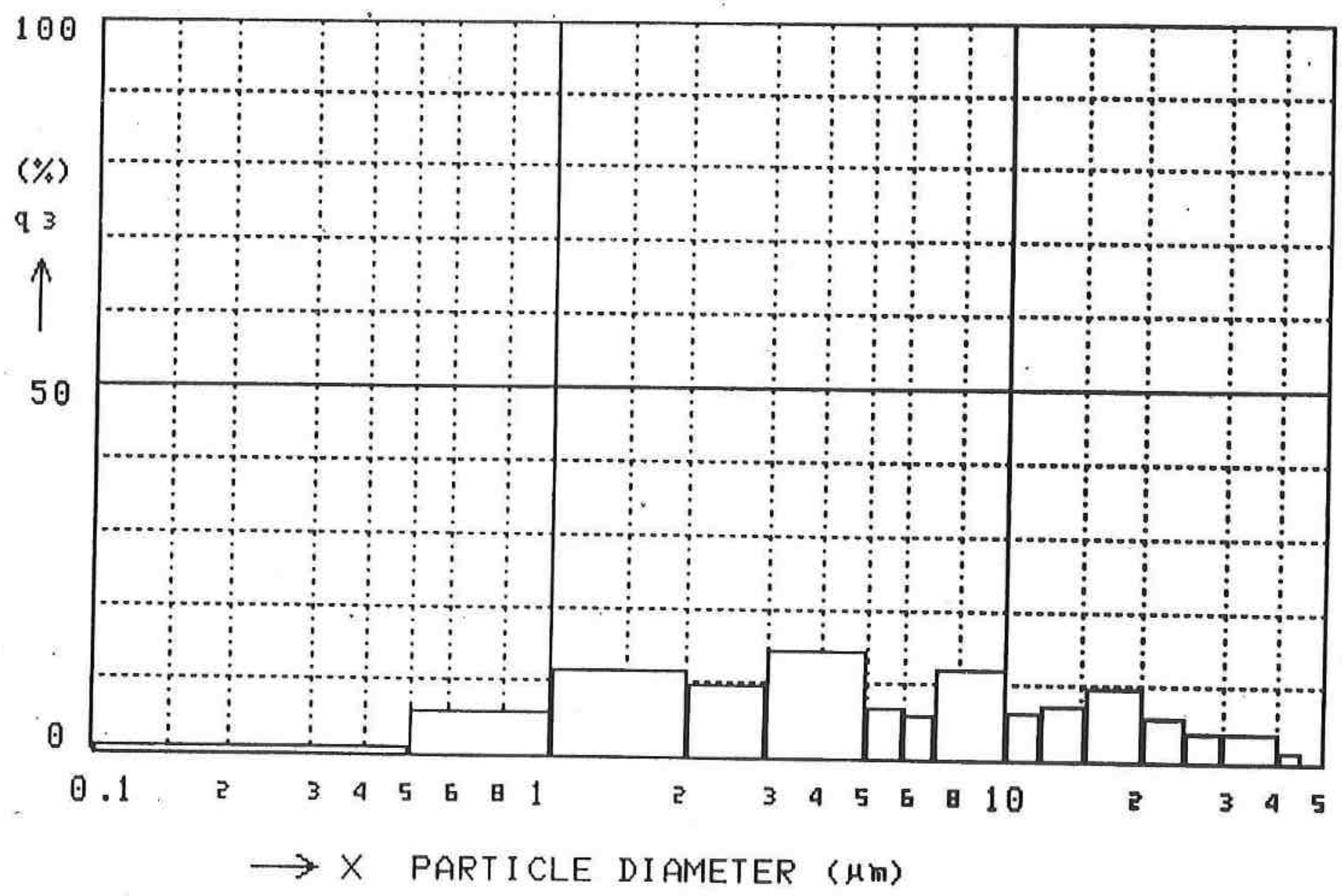


Fig. 4.8 Differential Distribution Graph : Source
(Murugan BM - Alathur Gate)

Table 4.4
Particle Size Distribution Data : Source (Murgan - Alathur Gate)

Sl.No.	Dia. (µm)	Diff.(%)	Cum. (%)	Dia. (µm)	Cum.(%)
1.	45		100.0	22.78	90
2.	40	1.3	98.7	19.27	85
3.	30	3.4	95.4	16.54	80
4.	25	3.5	91.8	14.14	75
5.	20	5.6	86.2	12.08	70
6.	15	9.3	76.9	10.32	65
7.	12	7.1	69.8	8.81	60
8.	10	5.8	64.0	7.53	55
9.	7	11.6	52.4	6.54	50
10.	6	5.5	46.9	5.69	45
11.	5	6.2	40.7	4.89	40
12.	3	14.2	26.4	4.16	35
13.	2	9.2	17.3	3.49	30
14.	1	11.0	6.2	2.26	20
15.	0.5	5.7	0.6	1.39	10
16.	0.1	0.6	0	0.88	5

Sl.No.	Dia. (µm)	Dif.(%)	Cum.(%)
1.	45.00 - 31.00	4.0	100.0
2.	31.00 - 22.00	6.7	96.0
3.	22.00 - 16.00	10.4	89.3
4.	16.00 - 11.00	11.9	78.9
5.	11.00 - 7.50	12.1	67.0
6.	7.50 - 5.30	12.4	54.9
7.	5.30 - 3.70	11.1	42.5
8.	3.70 - 2.60	8.3	31.4
9.	2.60 - 1.80	8.2	23.1
10.	1.80 - 1.30	6.1	14.9
11.	1.30 - 0.88	3.8	8.8
12.	0.88 - 0.60	3.9	5.0
13.	0.60 - 0.43	1.1	1.1
14.	0.43 - 0.30	0.1	0.1
15.	0.30 - 0.17	0	0
16.	0.17 - 0.10	0	0
17.	0.10		0

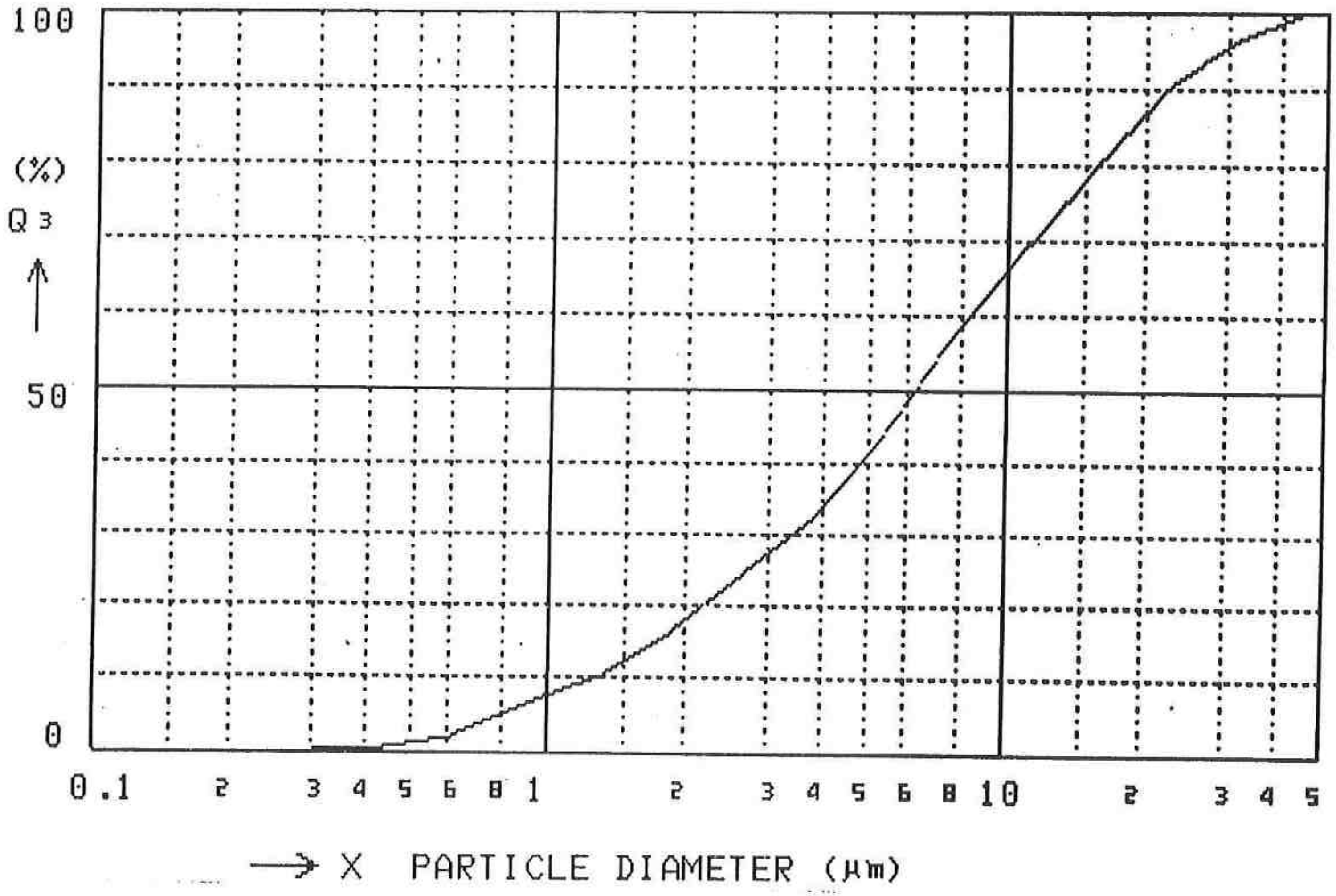


Fig. 4.9 Cumulative Distribution Graph : Ambient Air (Pammal)

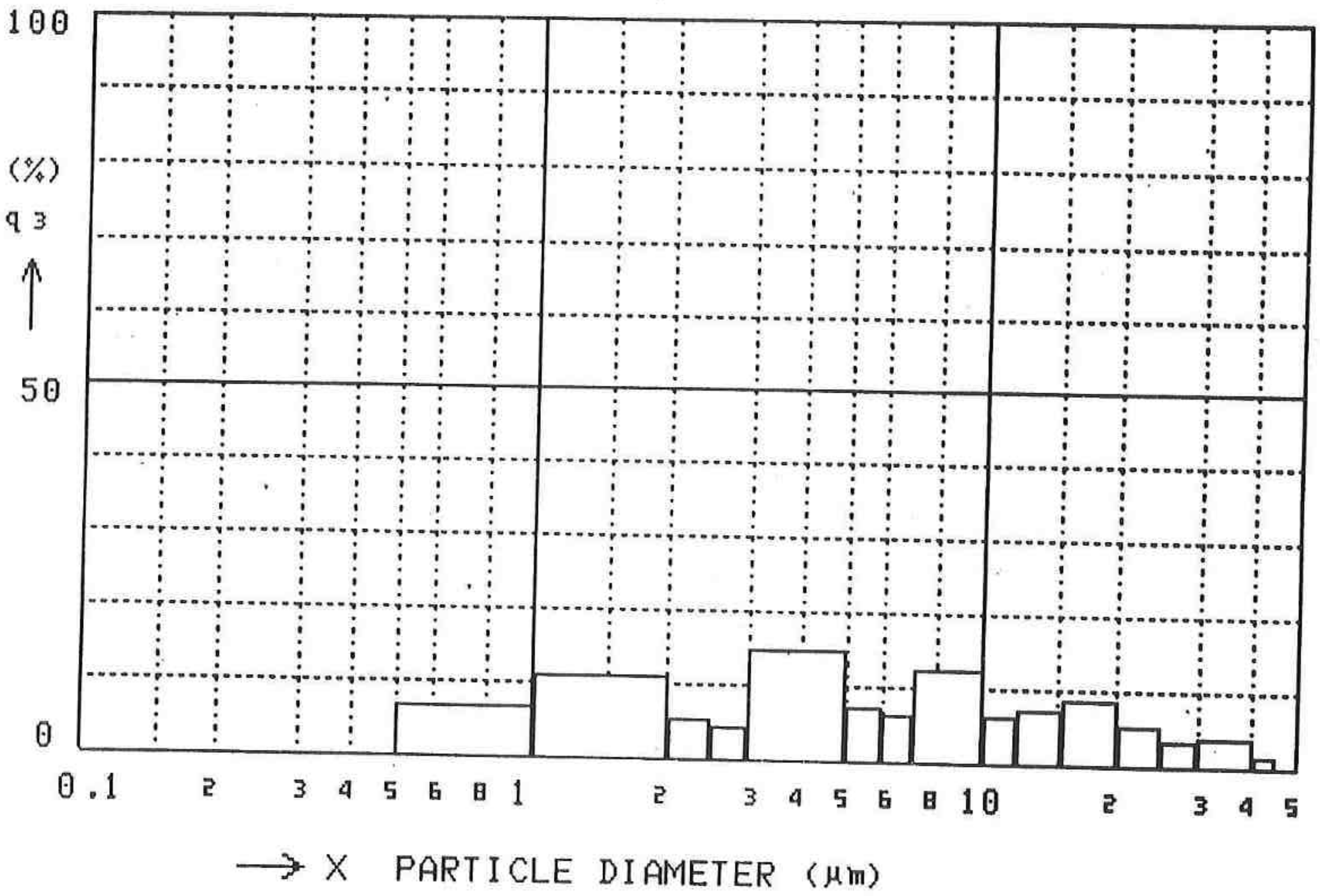


Fig. 4.10 Differential Distribution Graph : Ambient Air (Pammal)

Table 4.5

Particle Size Distribution Data in Ambient Air (Pammal - Chennai)

Sl.No.	Dia. (µm)	Diff.(%)	Cum. (%)	Dia. (µm)	Cum.(%)
1.	45		100.0	22.20	90
2.	40	1.4	98.6	18.57	85
3.	**30**	**3.5**	**95.2**	**15.60**	**80**
4.	25	3.1	92.0	13.21	75
5.	20	4.9	87.1	11.19	70
6.	**15**	**8.3**	**78.8**	**9.61**	**65**
7.	12	6.7	72.1	8.26	60
8.	**10**	**5.8**	**66.3**	**7.16**	**55**
9.	7	112.2	54.1	6.29	50
10.	6	6.0	48.2	5.53	45
11.	5	6.7	41.5	4.77	40
12.	3	14.7	26.8	4.09	35
13.	2.5	**4.2**	**22.6**	**4.43**	**30**
14.	2	4.8	17.7	2.22	20
15.	1.0	10.6	7.2	1.33	10
16.	0.5	6.2	0.9	0.80	5

Sl.No.	Dia. (µm)	Diff.(%)	Cum.(%)
1.	45.00 - 31.00	4.3	100.0
2.	31.00 - 22.00	5.9	95.7
3.	22.00 - 16.00	9.1	89.8
4.	16.00 - 11.00	11.3	80.8
5.	11.00 - 7.50	12.7	69.5
6.	7.50 - 5.30	13.4	56.8
7.	5.30 - 3.70	11.6	43.4
8.	3.70 - 2.60	8.4	31.8
9.	2.60 - 1.80	8.0	23.4
10.	1.80 - 1.30	5.8	15.4
11.	1.30 - 0.88	3.6	9.6
12.	0.88 - 0.60	4.1	6.0
13.	0.60 - 0.43	1.6	1.8
14.	0.43 - 0.30	0.2	0.2
15.	0.30 - 0.17	0	0
16.	0.17 - 0.10	0	0
17.	0.10		0

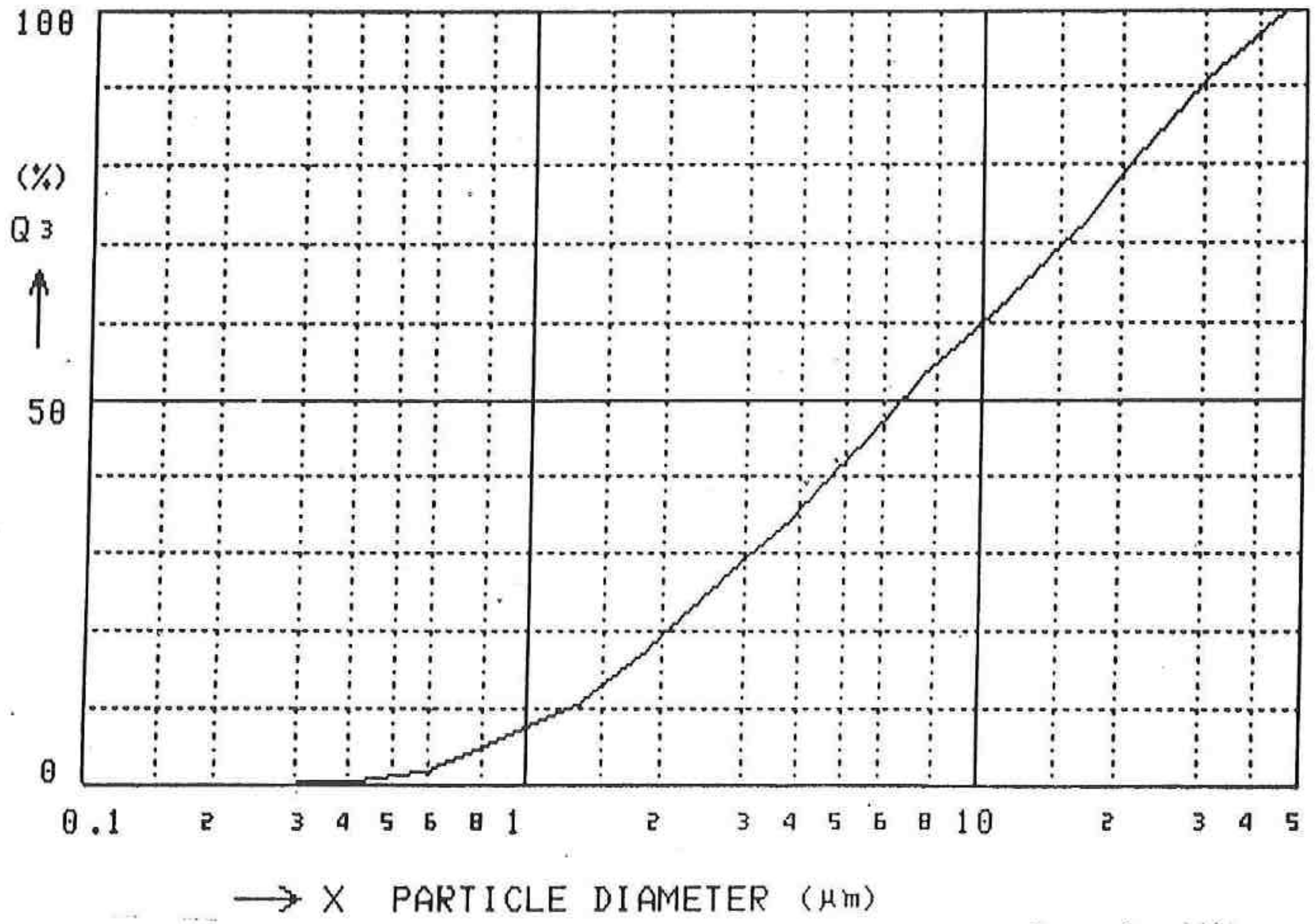


Fig. 4.11 Cumulative Distribution Graph : Ambient Air (Alathur Gate)

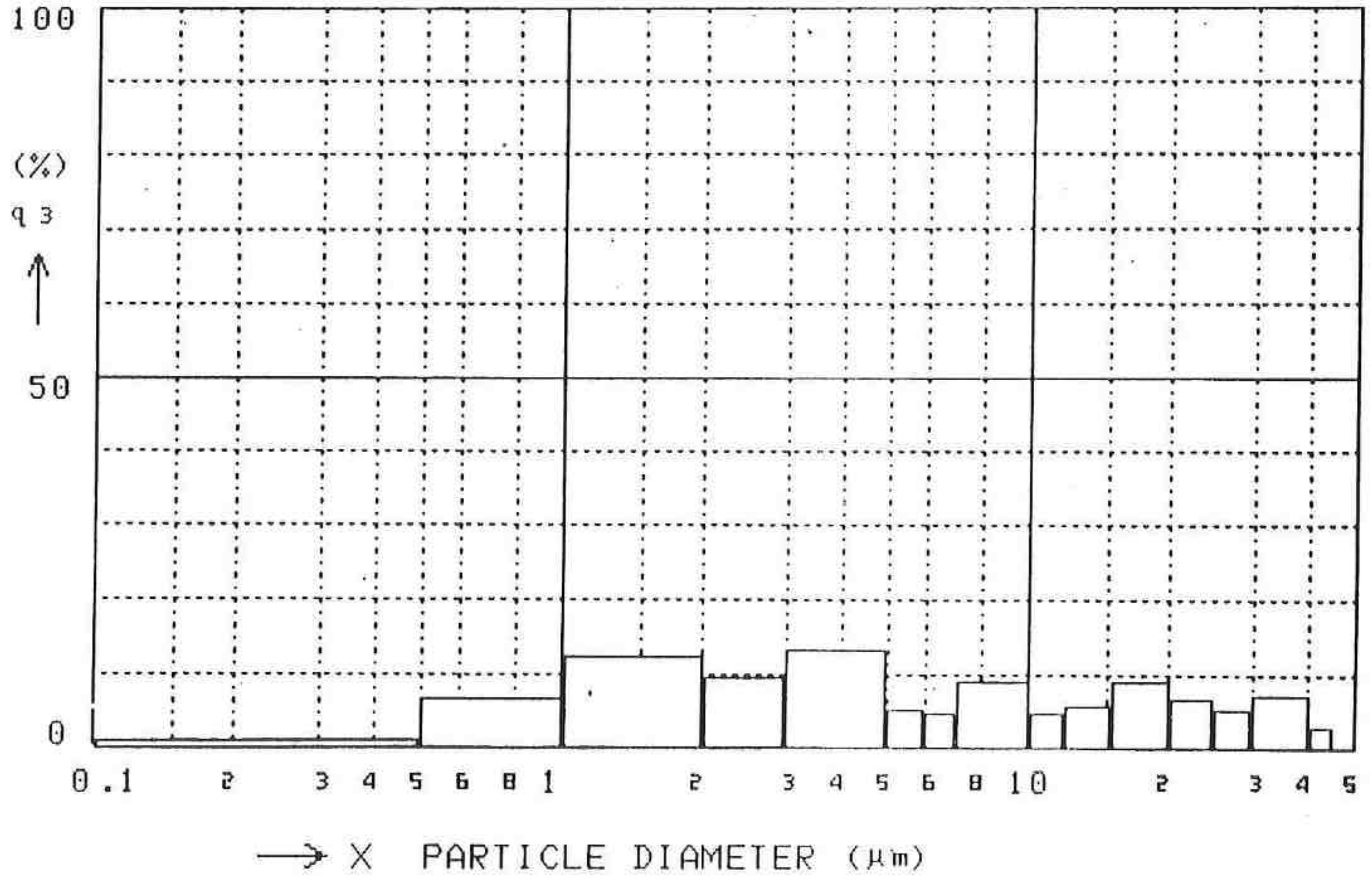


Fig. 4.12 Differential Distribution Graph : Ambient Air (Alathur Gate)

Table 4.6
Particle Size Distribution Data in Ambient Air (Alathur, Perambalur)

Sl.No.	Dia. (µm)	Diff.(%)	Cum.(%)	Dia. (µm)	Cum.(%)
1.	45		100.0	29.83	90
2.	40	2.8	97.2	24.78	85
3.	**30**	**7.0**	**90.2**	**20.81**	**80**
4.	25	4.9	85.2	17.84	75
5.	20	6.5	78.7	15.06	70
6.	**15**	**8.8**	**69.9**	**12.28**	**65**
7.	12	5.5	64.4	9.96	60
8.	**10**	**4.3**	**60.1**	**8.03**	**55**
9.	7	8.6	51.5	6.64	50
10.	6	4.4	47.1	5.57	45
11.	5	5.1	42.0	4.64	40
12.	**3**	**13.1**	**28.9**	**3.87**	**35**
13.	2	9.5	19.4	3.14	30
14.	1	12.1	7.3	2.05	20
15.	0.5	6.6	0.8	1.28	10
16.	0.1	0.8	0	0.81	5

Sl.No.	Dia. (µm)	Diff.(%)	Cum.(%)
1.	45.00 - 31.00	9.0	100.0
2.	31.00 - 22.00	9.2	91.0
3.	22.00 - 16.00	10.3	81.8
4.	16.00 - 11.00	9.2	71.5
5.	11.00 - 7.50	8.9	62.3
6.	7.50 - 5.30	9.8	53.4
7.	5.30 - 3.70	9.8	43.6
8.	3.70 - 2.60	8.2	33.8
9.	2.60 - 1.80	8.7	25.6
10.	1.80 - 1.30	6.7	16.9
11.	1.30 - 0.88	4.2	10.2
12.	0.88 - 0.60	4.4	5.9
13.	0.60 - 0.43	1.4	1.6
14.	0.43 - 0.30	0.1	0.1
15.	0.30 - 0.17	0	0
16.	0.17 - 0.10	0	0
17.	0.10		0

Table 4.7

$PM_{2.5}$ Concentration in SPM Samples Collected at Source and Ambient Air

Sl. No.	Sampling Location	Source/ Ambient	SPM ($\mu g/m^3$)	$PM_{2.5}$ (%)	$PM_{2.5}$ Concentration ($\mu g/m^3$)
1.	KVS BM, Pammal	Source	823	10.3	85
2.	Kavasam BM, Pammal	Source	1229	15.7	193
3.	KTC BM, Pammal	Source	402	17.0	68
4.	Murugan BM, Alathur	Source	127	23.1	29
5.	Open Land East of Vigneshwara BM, Pammal	Ambient Air	150	22.6	34
6.	Open Land West of Colony, Alathur Gate	Ambient Air	43	25.6	11

5.0 Conclusions and Recommendations

5.1 Conclusions

5.1.1 Pammal, Chennai

* In Pammal area there are 48 crushing units where particulate sampling was carried out during 4-8 October 1997, both at source and in the ambient air

* During the study each crusher was processing 40 MT/day

* The parameters studied were SPM, RPM and cyclone dust at the sources and ambient air

* The ambient particulate sampling was carried out in the predominant upwind and downwind directions at different distances from the source, at 50,100,200 and 500m

* SPM, RPM and cyclone dust concentrations nearer to the source were found to be high

* Ambient SPM concentrations in the Kamarajapuram site were highest during different phases of sampling. These concentrations which exceeded the standards are due to the proximity of the sampling site to the entry point to the crushing area. And also it is the entry point for all the heavy vehicles going into and out of the stone crushing area. The roads leading to the stone crushing site is not a pukka one resulting in reentrainment of dust from surface

* The other SPM concentrations at all the other sampling sites in different directions and distances were within the standards for residential zone except one value at Pudur house (100m) which was 211 μg/m^3. This is probably because of the higher background SPM concentrations in the region

* The contribution of one crusher to the SPM concentration was found to vary from 10 μg/m^3 to 70 μg/m^3 at 500 to 50m distance respectively

* The contribution of all the crushers to the SPM concentration was found to vary from 35 μg/m^3 to 135 μg/m^3 at 500 to 50m distance respectively

* The background SPM concentration was found to vary from 61 μg/m^3 to 140 μg/m^3 at the 500 to 50m distances

* During the study period the predominant wind directions were SW, W and SE

* The estimated emission rate for the 48 crushers was 294 kg/day

* The $PM_{2.5}$ concentration in the SPM was found to be 34 μg/m^3

5.1.2 Alathur Gate, Perambalur

* There are only 4 crushers operating in the cluster
* The average crushing activity carried out was about 60 MT/day/crusher
* RPM concentration was found to be within the standards
* The SPM concentrations were also found to be within the standards prescribed
* The background RPM and SPM concentrations were also found to be much lower compared to the ones observed at Pammal, Chennai
* The predominant wind directions during the study period were North and Northeast
* The emission rate for dust generation was found to be 10 kg/day
* $PM_{2.5}$ concentration was 11 $\mu g/m^3$ in ambient air

5.2 Recommendations

5.2.1 Pammal, Chennai

* A minimum distance of 200m with a green belt of 100m width should be provided around the periphery of the crushing area

* Raising a green belt around the crushing area to arrest the spread of particulate matter is advocated along the boundary of the crushing area on all the sides with evergreen high foliage trees like Neem, Ashoka, Coconut, Tamarind and other local trees

belonging to *cesalfinaceae* like Gul Mohar and Fire of the Forest. On road sides also trees can be planted to arrest the dust from vehicular movement

* Though the observed SPM concentrations were within the standards prescribed, except one value, it is recommended that the sprinkling of water should be increased to arrest the spread of dust (RPM & SPM) with periodical cleaning of spray nozzles

* Fine dust accumulated in the crushing area should be periodically cleared and the dumps should be covered with tarpaulins to arrest the spread of dust

* The approach roads should be properly laid with tar or concrete and should be sprayed with water, starting at the entry point to the crushing area and to the individual crushers

* No more crushing units should be allowed in this area

* The drop height should be kept at a minimum while loading and unloading

* Conveyor chutes should be provided at the discharge points

* Special recommendation for RTC BM company - As it is at the entry point to the crushing area should be provided with an

enclosure of suitable material (brick) to a height of 5m on the North, East and Western sides

* It is suggested that a thorough study be carried out during the summer season when dust concentrations would be higher

* As an occupational safety measure all the workers should be provided with nose masks to avoid dust entering the respiratory system

5.2.2 Alathur Gate, Perambalur

* The minimum distance from the source should be kept as 85m with a 15m green belt within it at the periphery

* Evergreen trees like Neem, Ashoka, Tamarind and other local trees belonging to the family *cesalfinaceae* like Gul Mohar and Fire of the Forest may be planted all around the crushing area. Similarly trees may be planted along the roads to arrest the spread of particulate arising from vehicular movement inside the area

* Roads leading to the individual crushers should be paved

* The fine powder accumulated so far should be immediately disposed off and the crushers should follow periodical disposal practice in consultation with TNPCB

* Good house-keeping by way of spraying water at the vulnerable points/locations to arrest the spread of dust particles should be practiced

* Drop height of the conveyors should be kept at the minimum

* Conveyor chutes should be provided at the discharge points

* As an occupational safety measure all the workers should be provided with nose masks to avoid particulates entering the respiratory system

* Even though the concentrations are well within limits, in view of the presence of the National Highway, the individual units should be enclosed with suitable brick walls of 5m height

* Though the observed SPM and RPM concentrations were within the limits probably due to the lesser number of crushing units, it is necessary to carryout a study during the summer season when dust concentrations would be higher

* Ambient air quality monitoring should be carried out during summer in the downwind and upwind directions

5.2.3 General Recommendations for a Single Crusher

Based on the studies conducted at Pammal Stone crushing area and at Alathur crushing area with operating only one crusher the following recommendations are made :

* NPC dust containment and dust suppression system should be provided
* Paving of roads should be adopted
* Green belt for 10m within a distance of 50m should be provided around the crusher
* Fine powder should be collected at the ground level
* Conveyor chute should be provided at the discharge points
* Drop height for conveyor operations should kept at the minimum
* Ambient air quality monitoring with respect to SPM should be carried out in both the downwind and upwind directions during summer
* The fine powder should be disposed off periodically
* Covering of fine dust with tarpaulin during storage and transport to final destination should be practiced

ANNEXURE I

CPCB STANDARDS FOR SUSPENDED PARTICULATE MATTER FROM STONE CRUSHING UNIT

The standards consist of two parts :

i) Implementation of the following pollution control measures :

a) Dust containment cum suppression system for the equipment.

b) Construction of wind breaking walls.

c) Construction of the metalled roads within the premises.

d) Regular cleaning and wetting of the ground within the premises.

e) Growing of a green belt along the periphery.

ii) Quantitative standard for the SPM :

The suspended particulate matter measured between 3 meters to 10 meters from any process equipment of a stone crushing unit shall not exceed 600 $\mu g/m^3$

Source : EPA Notification
[G.S.R. 742E) dt.30th Aug; 1990

ANNEXURE II

NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutants	Time weighted average	Concentration in ambient air			Method of Measurement
		Industrial Area	Residential, Rural & other areas	Sensitive of Area	
1	2	3	4	5	6
Sulphur Dioxide (SO_2)	Annual Average*	80 µg/m^3	60 µg/m^3	15 µg/m^3	1. Improved West and Gaeke
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	2. Ultraviolet fluorescence
Oxides of Nitrogen as NO_2	Annual Average* 24 hours**	80 µg/m^3	60 µg/m^3	15 µg/m^3	1. Jacob & Hochheiser modified (Na-Arsenite) Method
	24 hours**	120 µg/m^3	80 µg/m^3	30 µg/m^3	2. -Gas Phase Chemlluminescence
Suspended Particulate Matter (SPM)	Annual Average*	360 µg/m^3	140 µg/m^3	70 µg/m^3	- High Volume Sampling, (Average flow rate not less than 1.1 m^3/minute)
	24 hours**	500 µg/m^3	200 µg/m^3	100 µg/m^3	
Respirable Particulate matter (size less than 10 µm) (RPM)	Annual Average*	120 µg/m^3	60 µg/m^3	50 µg/m^3	Respirable particulate matter sampler
	24 hours**	150 µg/m^3	100 µg/m^3	75 µg/m^3	
Lead (Pb)	Annual Average*	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3	- AAS method after sampling
	24 hours**	1.5 µg/m^3	1.00 µg/m^3	0.75 µg/m^3	Using EPM 2000 or equivalent Filter Paper
Carbon Monoxide (CO)	8 hours**	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/m^3	- Non dispersive infrared spectroscopy
	1 hour	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3	

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

NOTE :

1. National Ambient Air Quality Standard : The levels of air quality with an adequate margin of safety, to protect the public health, vegetation and property.
2. Whenevery and whenever two consecutive values exceeds the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.
3. The State Government/State Board shall notify the sensitive and other areas in the respective states within a period of six months from the date of Notification of National Ambient Air Quality Standards.

[S.O. 384(E), Air (Prevention & Control of Pollution)
Act, 1981 dated April 11, 1994]