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6035115



RESPIRABLE PARTICULATES STUDY IN DEVELOPING TOWNS OF KERIAN & SEBERANG PERAI SELATAN DISTRICTS

NOR AZAM BIN RAMLI
BAHAGIAN KEJURUTERAAN ALAM SEKITAR
PUSAT PENGAJIAN KEJURUTERAAN AWAM
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PENGHARGAAN

KAMI INGIN MERAKAMKAN UCAPAN TERIMA KASIH YANG TIDAK TERHINGGA DI ATAS KESUDIAN PIHAK UNIVERSITI SAINS MALAYSIA MELULUSKAN GERAN PENYELIDIKAN INI.

SEMOGA DIMASA AKAN DATANG KUMPULAN PENYELIDIKAN ALAM SEKITAR DI PUSAT PENGAJIAN KEJURUTERAAN AWAM INI AKAN DIKURNIAKAN DENGAN GERAN-GERAN UNTUK TUJUAN PEMAJUAN BIDANG TUMPUAN KUALITI UDARA DAN KAJIAN IMPAK ALAM SEKITAR TERUTAMA DALAM PEMBINAAN KEUPAYAAN DAN PENINGKATAN KEMAHIRAN SUMBER MANUSIA.

RINGKASAN TEKNIKAL

A Study on Physical and Chemical Characteristics of Airborne Particulate Matter in Developing Town (Case Study in Parit Buntar and Nibong Tebal)

N.A. Ramli, A.H. Ibrahim, W.H.W. Ibrahim, A.S. Yahya
School of Civil Engineering, Universiti Sains Malaysia (USM), Nibong Tebal, Penang.

Abstact

This research is being done to investigate the physical and chemical properties of airborne particulate matters (PM) from Nibong Tebal and Parit Buntar. Non-reactive carbon layer is glued onto a stub to collect airborne particulate matters from the atmosphere. The stub was exposed to the ambient atmosphere for 24 hours to allow the particulate matter to deposit onto it. PM sample from vehicles exhaust also being collected and analyzed in order to see the association between the vehicles as a source of particulate matter. The stubs then are placed directly into the Scanning Electron Microscope (SEM) to analyze their images. Chemical compositions of those particulate matters are being analyzed by using Energy Dispersive X-ray equipment that is presences as an accessory to the SEM. The electron microscope (SEM) used was a Leo Supra 50 VP while Energy Dispersive X-ray equipment used was Oxford Inca 400. From the research, it was found that the greatest contribution to particulate matters mass collected in Parit Buntar and Nibong Tebal are carbon (organic carbon or/ and elemental carbon), O, Al, Si and other species such as Ca, K, Fe and Mg. These elements probably come from earth crust mineral and particles from vehicles exhaust as well as factories nearby. While the size is varies from 7.9 μm to 158 μm and can be categorized as coarse particles.

Keyword: Particulate matter, Chemical Composition, Vehicles exhaust.

1.0 Introduction

Cities and towns are always being picture as abundant of populations, activities and materials. They therefore show the highest level of air pollution and being the largest target of impact. This phenomenon becomes worse with the presences of industrial areas around the town. Uncontrolled stacks emission from factories can also contribute to bad air quality to the town atmosphere. Construction activities, especially the dust from the construction sites and vehicles emission also play a role polluting the town atmosphere.

Air pollution is the important point of our concern because it affects people, ecosystem, plant, and building and monumental stones adversely. Air pollution can define as changed of air quality by addition of particles, gases, or energy forms (e.g., heat, radiation or noise) so that the altered atmosphere poses some harm (Godish, 1997).

In Malaysia, there are three main sources of air pollutants, mobile sources, stationary sources and open burning sources (Afroz et al., 2001). These sources emit varies of air pollutants such as carbon monoxide (CO), sulfur dioxide (SO_2), particulate matters (PM) and etc. However, in Malaysia, five pollutants have been categorized as criteria pollutants and being monitor continuously. These five air pollutants are carbon

monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxides (NO_2), ozone (O_3) and particulate matter below than 10μm in size (PM_{10}) (DOE, 2002).

Health impact due to air pollution exposure can be divided into two categories, short-term and long-term effect. Short-term effects occur when the pollution level is very high and end with acute condition. However, long term effects are unknown and hard to trace. Some pollutants are carcinogenic and the effects appear only after a few years of exposure. The result also can be more serious for children, for whom the particulates inhaled relatively high to body size (Afroz et al., 2001).

Researches have constantly demonstrated bad effects of particulate matter (PM) exposure on human health. The studies show that exposure to airborne particulate matter is connected with an increase incidence in both respiratory and cardiac disease. Although the affect of particulate matter to human health is given priority, the negative effects on plant, ecosystem, building and monumental stones should not be neglected.

During the haze episode back in September 1997, researchers found that particulate matter contributes most of the haze component compared to gases. During the hit, number of patient suffer to respiratory problem had increased. Example in Kuala Lumpur, patient came to get treatment because of respiratory problems increased from 250 to 800 per day while in Kuching, the number of patient increased two to three times during the peak time of smoke haze (Afroz et al., 2001).

However, in this research, not all air pollutants being studied. Only particulate matter is given a consideration. Sample of particulate matters (PM) were collected and being analyzed to gain information of its chemical compositions and images. Research should be carried out intensively in order to build our knowledge in this area, thus give us more idea to handle this sort of problems. One of the great issues is whether the chemical or physical properties are important for its effect on health (Harrison and Yin, 2000).

2.0 Experiment

2.1 Particle sampling from area of interest

In this project, particulate matters from the ambient atmosphere of Nibong Tebal and Parit Buntar have been studied. The following sampling methodology was carried out to collect sample from the atmosphere:

- Particles deposited on horizontal non-reactive surface (carbon layer) sheltered from rainfall. Figure 2.0 shows the non-reactive carbon layer that later being glued onto studs while Figure 2.1 shows the aluminium stubs.

Particles deposited on these carbon surfaces in a continuous way. These studs were exposed to the ambient atmosphere for 24 hours to allow the particulate matter to deposit onto it. The stubs were placed about 1.5 m from the land surface. Stubs that have been exposed to the atmosphere for 24 hour are then being stored in petri dish and ready to be analyzed.

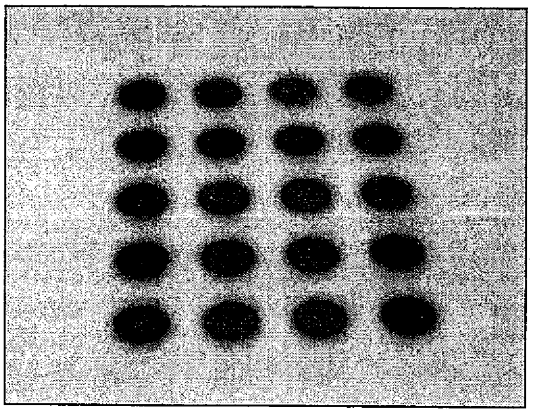


Figure 2.0: Non-reactive carbon layer.

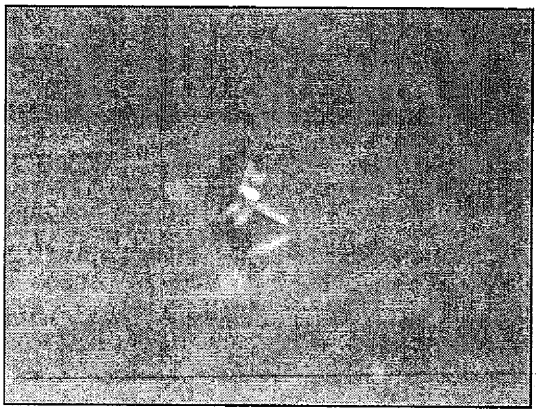


Figure 2.1: Aluminium stud.

2.2 Sampling area

In Nibong Tebal and Parit Buntar area, 10 locations in each area have been identified to be the sampling location. Map of the towns were used to determine the sampling site that best represent the town area. Maps were provided by the local authority.

2.3 Sampling site categories

In order to do sampling, site of sampling are divided into two categories. Those categories are:

- Type 1: Urban site.

Locate stud in the central business district of the urban area on a congested, downtown street surrounded by buildings and having many pedestrians.

- Type 2: Rural site.

Locate stud out of central business district of the urban area but quite close to major streets.

Table 2.0 and table 2.1 show the sampling area arranged according to the sampling site categories.

Table 2.0: Sampling sites locations in Nibong Tebal.

NIBONG TEBAL	
URBAN SITE	RURAL SITE
Pusat Bandar Nibong Tebal (PB NTEBAL)	Sek. Keb. Trankerian (SK KERIAN)
Maybank Nibong Tebal (MAYBANK)	Sungai Bakap (SG BAKAP)
Tepi Sungai (TEPI SUNGAI)	Permatang Keling (P KELING)
Teluk Ipil (TELUK IPIL)	Sek Men. Teknik Nibong Tebal (SM TEKNIK)
Jawi (JAWI)	Sek Men. Sri Nibong (SM SRI NIBONG)

Table 2.1: Sampling sites locations in Parit Buntar.

PARIT BUNTAR	
URBAN SITE	RURAL SITE
Pusat Bandar (PUSAT BANDAR)	Kilang padi (KILANG PADI)
Pekan Lama (PEKAN LAMA)	Kompleks Sekolah (KOMPLEKS SEKOLAH)
Pekan Baru (PEKAN BARU)	Simpang Empat Taiping – Parit Buntar (SMPG4 TAIPING – PB)
Clock Tower (CLOCK TOWER)	Sempadan Perak – Pulau Pinang (PRK-PP)
Hotel Damai (HOTEL DAMAI)	Majlis Daerah Kerian (MDK)

2.4 Particle sampling from vehicles exhaust

Particles emitted from vehicles exhaust were collected by using the same devices (stud and non-reactive carbon tape). Non-reactive carbon tape was glued onto the stud. The height of the stud above the ground was equal to that of the outlet orifice of the exhaust gas. The stud was pointed towards the outlet orifice and located at a distance of 1 foot from the orifice. The stud was exposed for 15 minutes. Exposed studs were then kept in the petry dish and ready to be analyzed.

2.5 Type of vehicle

Gases emitted from six types of vehicles were being sampled. The vehicles were:

1. Bus (Hino, 7961 cc, year 2001)
2. Pick Up (Suzuki, 1360 cc, year 1994)
3. Car above 1000cc (Proton Wira 1600 cc, year 1996)
4. Car below 1000cc (Perodua Kancil, 660cc, year 2003)
5. 2-stroke motorcycle (Yamaha SS, 110 cc, year 1996)
6. 4-stroke motorcycle (Honda Ex-5 100 cc, year 2000)

2.6 Instrumental technique

X-ray mapping by SEM-EDX have been carried out in all the cases (particle bulk analysis)

The electron microscope (SEM) used was a Leo Supra 50 VP while Energy Dispersive X-ray equipment used was Oxford Inca 400. A scanning electron microscope (SEM) is used to observe the physical appearance and to record the digital images of the particles samples while EDX is use to analyze the chemical composition of the particulate matters. Before putting the samples into the SEM-EDX to be analyze, those samples were coated with Aurum (about 20 nm thick) by using sputter coater, Polaron SC 515.

3.0 Result and discussion

Table 3.0, Table 3.1, Table 3.2 and Table 3.3 show the elements presence in the particles in table form. It is arranged in table manner to make it easier to identify the differences or similarities between the particles.

Table 3.0: Elements in particles collected in Parit Buntar

LOCATION	ELEMENTS													
	Al	**Ca**	**Cl**	**Cu**	**Fe**	**K**	**Mg**	**Na**	**Si**	**S**	**Ti**	**C**	**O**	**Zr**
KILANG PADI														
spot 1	*					*			*			*	*	
spot 2	*				*							*	*	
spot 3	*					*		*	*			*	*	
KOMPLEKS SEKOLAH														
spot 1	*				*	*	*		*			*	*	
spot 2	*				*			*	*			*	*	
spot 3	*	*	*		*		*	*	*	*		*	*	
PEKAN BARU														
spot 1	*				*				*			*	*	
spot 2				*	*				*	*	*		*	
spot 3	*				*	*		*	*			*	*	
PEKAN LAMA														
spot 1	*				*	*	*		*			*	*	
spot 2	*					*			*			*	*	
spot 3	*				*				*			*	*	
PUSAT BANDAR														
spot 1		*					*		*	*		*	*	
spot 2	*				*		*		*			*	*	
spot 3	*					*			*			*	*	
CLOCK TOWER														
spot 1	*	*							*			*	*	*
spot 2	*							*	*			*	*	
spot 3	*	*						*	*	*		*	*	

Table 3.0: continue

HOTEL DAMAI														
spot 1	*					*			*			*	*	
spot 2									*			*	*	
spot 3	*					*		*	*	*			*	
MDK														
spot 1	*	*				*			*			*	*	
spot 2	*				*		*		*			*	*	
spot 3	*								*			*	*	
PRK -PP														
spot 1					*				*	*	*	*	*	
spot 2			*		*							*	*	
spot 3	*				*	*	*		*			*	*	
SMPG4 TAIPING-PB														
spot 1	*				*		*		*			*	*	
spot 2	*								*			*	*	
spot 3	*				*				*			*	*	

* Element presents in particle

Table 3.1: Elements in particles collected in Nibong Tebal.

LOCATION	ELEMENTS												
	Al	Ca	Cl	Fe	K	Mg	Na	Si	S	C	O	P	N
MAYBANK													
spot 1	*	*						*		*	*		
spot 2	*									*	*		
spot 3	*				*		*	*			*		
SM SRI NIBONG													
spot 1	*			*			*	*		*	*		
spot 2	*							*		*	*		
spot 3	*				*			*		*	*		
SM TEKNIK													
spot 1	*							*		*	*		
spot 2	*				*			*		*	*		
spot 3	*			*			*	*		*	*		
TELUK IPIL													
spot 1								*		*	*		
spot 2	*			*	*	*		*		*	*		
spot 3								*		*	*		
TEPI SUNGAI													
spot 1	*				*	*		*		*	*		
spot 2								*			*		
spot 3	*				*			*			*		
JAWI													
spot 1	*							*		*	*		
spot 2	*	*					*	*		*	*		
spot 3	*				*		*	*		*	*		

Table 3.1: continue

P KELING													
spot 1	*			*				*		*	*		
spot 2	*						*	*		*	*		
spot 3	*			*	*			*		*	*		
SK KERIAN													
spot 1	*						*	*		*	*		
spot 2	*				*		*	*		*	*		
spot 3	*			*				*		*	*		
PB NTEBAL													
spot 1	*			*				*		*	*		
spot 2		*			*	*	*			*	*	*	*
spot 3				*						*	*		
SG BAKAP													
spot 1	*			*				*		*	*		
spot 2	*			*	*		*	*	*	*	*		
spot 3	*				*			*		*	*		

* Element presents in particle

Table 3.2: Elements in particles collected from vehicle exhaust.

TYPE OF VEHICLE	ELEMENTS															
	Al	Ca	Cl	Cu	Fe	K	Mg	Na	Si	S	Ti	C	O	Pb	Zn	P
BUS																
spot 1	*				*				*			*	*			
spot 2	*		*		*		*	*	*	*		*	*			
spot 3									*	*		*	*			
PICK UP																
spot 1	*	*					*			*		*	*	*	*	
spot 2												*	*			
spot 3												*	*	*	*	
CAR ABOVE 1000CC																
spot 1	*				*			*	*	*		*	*			
spot 2								*		*		*	*			*
spot 3								*	*	*		*	*			
CAR BELOW 1000CC																
spot 1								*		*		*	*			*
spot 2								*		*		*	*			*
spot 3								*		*		*	*			
2-STROKE MOTORCYCLE																
spot 1		*										*	*			
spot 2								*		*		*	*			
spot 3								*		*		*	*			

Table 3.2: continue

4-STROKE MOTORCYCLE																
spot 1									*			*	*			
spot 2			*					*		*		*	*			
spot 3		*								*		*	*		*	*

* Element presents in particle

Table 3.3: Elements in particles collected from the bottom outlet of palm oil mill cyclone.

	ELEMENTS															
	Al	**Ca**	**Cl**	**Cu**	**Fe**	**K**	**Mg**	**Na**	**Si**	**S**	**Ti**	**C**	**O**	**Pb**	**Zn**	**P**
CYCLONE																
spot 1			*			*			*			*	*			
spot 2												*	*			
spot 3		*	*			*			*			*	*			

* Element presents in particle

Table 3.4 shows the size of each particle that had been analyzed using Scanning Electron Microscope (SEM).

Table 3.4: Size of particle.

Samples from Parit Buntar	**Size (µm)**	**Samples from Nibong Tebal**	**Size (µm)**
KILANG PADI		SEK TRANS	
spot 1	129	spot 1	14.1
spot 2	114.5	spot 2	8.3
spot 3	125.8	spot 3	7.9
PUSAT BANDAR		JAWI	
spot 1	35.6	spot 1	53.3
spot 2	33.3	spot 2	19.7
spot 3	36.5	spot 3	4.8
PEKAN LAMA		PB. N TEBAL	
spot 1	71.9	spot 1	19.4
spot 2	42.6	spot 2	7.5
spot 3	58.05	spot 3	7.5
PEKAN BARU		SG BAKAP	
spot 1	49.5	spot 1	65
spot 2	101.6	spot 2	8.9
spot 3	38.13	spot 3	9
KOMPLEKS SEKOLAH		P. KELING	
spot 1	23.07	spot 1	30.8
spot 2	15.7	spot 2	10.4
spot 3	13.8	spot 3	25.3

Table 3.4: continue

SMPG4 TAIPING-PB		MAYBANK NT	
spot 1	72	spot 1	77.4
spot 2	48.7	spot 2	33.5
spot 3	35.2	spot 3	158.05
PRK-PP		SM TEKNIK	
spot 1	58.8	spot 1	71.1
spot 2	42.2	spot 2	77.4
spot 3	91.7	spot 3	36.3
HOTEL DAMAI		TEPI SUNGAI	
spot 1	106.5	spot 1	290.3
spot 2	86.7	spot 2	77.4
spot 3	38.1	spot 3	60.5
MDK		SM SRI NIBONG	
spot 1	110	spot 1	25.9
spot 2	82.2	spot 2	77.9
spot 3	82.2	spot 3	222.6
CLOK TOWER		TELUK IPIL	
spot 1	27.2	spot 1	75.5
spot 2	94.45	spot 2	85.5
spot 3	32	spot 3	74.1

Before the research being carried out, the hypothesis is that there are heavy metal presences as a main element in the particulate samples collected in Parit Buntar and Nibong Tebal. However, after the research being carried out, heavy metals are not the main elements of the particulate.

Research by (Ye Wu et al., 2003) mentioned that the greatest contribution of coarse paticles in urban and rural areas are organic carbon, elemental carbon, sulfate, nitrate, ammonium, Na, Cl and geological species such as Si, Ca, Al, Fe, K and Mg.

From the result obtained, it is believed that most of the partilces are from the earth crust. There are few points that make this statement make sense. The elements presence in all particles are closely same with the elements presence in the earth crust. There are 10 most abuntant elements in earth crust namedly oxygen, silicon, aluminium, iron, calsium, sodium, magnesium, potassium, titanium and hidrogen with the percentage of weigth 46.1%, 28.2%, 8.23%, 5.63%, 4.15%, 2.36%, 2.09%, 0.565% and 0.14% respectively.

Refer to the Table 3.0 and 3.1, 50 out of 60 samples contain Al and 55 out of 60 samples contain Si while O present in all samples. O is very reactive with other elements. O bond as an O^{2-} anion to form compound called oxides. Other crustal species as mentioned above also presence in the sampel randomly. Mineral which combine Si and O elements are called silicates, and combined they are the most abundant minerals on the Earth (Lutgens and Turbuck, 2000). This point gives strong evidence that most of these particles are silicate minerals. Those particles could be olivine $(Mg,Fe)_2SiO_4$, Augite $(Mg,Fe)SiO_3$, Hornblende $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$, Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$, Muskovite $KAl_2(AlSi_3O_{10})(OH)_2$, orthoclase

$KAlSi_3O_8$, Plagioclase $(Ca,Na)AlSi_3O_8$ and quartz SiO_2. By looking to the empirical formula, it is possible that particles collected are probably silicate mineral. All elements can be seen present in the particles collected in Parit Buntar and Nibong Tebal.

At Kilang Padi sampling area, rice husk ash may also contribute particulate matter rich in Si content. Rice husk ash contains about 85 % Si. The size of rice husk is small, about 25 μm in diameter. This ash can be transported from the factory area to places nearby by with action (http:// ebigchina.com/ ebcps/4/pd/164663.html 6 April 2005).

Earth crust materials present in the air by certain action. Earth works at construction site contribute most of the presences of soil dust wind blown rock-derived material in the atmosphere. Dry surface and high wind speed tend to be favoured the suspension of these earth crust materials in the air. Construction work near the sampling site is one of the examples how crust material was introduced into the atmosphere. Construction site near Sek . Keb Transkerian is one of them.

Beside that these crust element also become resuspended due to the action of the wind turbulence induced by passing road traffic. Asphalt road pavement and concrete pavement contain crustal mineral as one of the component. Asphalt road contains quatz (SiO_2), calcite ($CaCO_3$), asphalt and iron oxide (FeO). Mean while concrete pavement is mixed of limestone aggregate ($CaCO_3$), iron oxide (FeO) and cement (Micron et al., 1979).

Beside the crustal material, other components may contribute to the chemical element of those particles. Fine particles may attach to the particles and make up the chemical elements of the particle. Particulate matter from the exhaust vehicles are much finer compare to the crustal material presences in the atmosphere and it is possible to attach to the coarse particulate. Gong and Beaglehole (2000) found that Al, Ca and S present in the diesel particulate samples 100% of the time. It is well known that diesel fuel contains S. Element S found in petrol samples might arise from lubrication oil (Gong and Beaglehole, 2000). Six samples from Parit Buntar and one sample from Nibong Tebal show the presence of S in the particulate matter. Studies of particulate matter emitted from all type of vehicles exhaust demonstrated the presence of S. This clearly shows vehicles are the main source of S that later contribute to element S in particulate matter samples collected in Parit Buntar and Nibong tebal.

Besides, as an abundant element is earth crust mineral, Fe also can be present into the atmosphere result of iron released into the atmosphere during high-temperature processes such as metal smelting industries (e.g Southern Steel in Nibong Tebal) (Merano et al., 2004). They are generally rounded and probably come from the combustion of fossil fuels. There are some are not rounded derived mainly from other industrial activities (Esbert et al., 2000).

Samples collected in Komplek Sekolah showed the presences of Cl. Main source of chloride are sea spray even at location hundreds of kilometers from the coast (Harrison et al., 2000). It is possible that these chlorides rich particles were blown from the sea to this area. From the Figure 3.0, we can notice that Nibong Tebal and

55 spots of the particulate matter analyzed by EDX analyses showed the presence of carbon. It is believe that elemental carbon and/ or organic carbon come from biological particles (spores and pollens) as well as those particles produced by the internal combustion of oil and petrol in vehicles. Such combustion produces organic compounds that condense in the air to form spherules smaller than 100 nm in diameter, this subsequently aggregate to form larger particles. Because of their small size and low density, these agglomerates can travel in air for long distances (Moreno et al., 2004). All sample collected from six type of vehicles contain C element. This result support that C element is mainly contribution of vehicles regardless what the type is.

P element present in particulate matter sample collected from Pusat Bandar Nibong Tebal. Obviously P is come from the cars and motorcycle with four-stroke engine. Both cars, Perodua Kancil and Proton Wira also the motorcycle show the presence of P in the particulate matter emitted from the exhaust. Sample from palm oil mill is free from P.

Sample from Pekan Baru and Sempadan Perak-Pulau Pinang contain Ti element. Ti is listed in ten most abundant elements in earth crust with 0.565% by weight. Sample from vehicles exhaust and palm oil mill are not showing any presence of Ti element. Hence, Ti might be come from the earth crust material or other sources such as brake dust produced by vehicle's brake system and also from the tyre dust (Adachi and Tainosho, 2004).

From the list of particle's size in Table 3.4, it shows that the particles are ranged from 7.9 μm to 158 μm. Particles in this range of size is grouped as a coarse paricles. Through the SEM images, shapes of those particulate collected can be divided into 2 group, circular and rod shape.

4.0 Conclusion

Chemical species components of particulate matters were measure near major roads, parks and background location in Parit Buntar and Nibong Tebal. The greatest contribution to total particulate matters are carbon (organic carbon or/and elemental carbon), Al, Si and O. K and Fe are two species that also frequently presence in the particles composition. Other species such as Ca, Cl, Cu, Mg, Na, Si, S, Ti, Zr, P and N are present randomly.

Particulate matter in Parit Buntar and Nibong Tebal can be categorized as coarse particles because of the size range. The sizes of the particles are from 7.9 μm to 158 μm. Particles sampled from Nibong Tebal and Parit Buntar can be group into two major different shape, rod shape and circular shape.

Crustal mineral had been identified as the main contributor to the most of the particulate matters in Parit Buntar and Nibong Tebal. Crustal materials are believed to be present due to wind blow on loose soil surfaces especially at a construction site. However, wind turbulence cause by vehicles moving fast on road also resuspended the road pavement dusts which contain crust mineral. Vehicles also emit particulate matter to the atmosphere. Analysis of particulate matter from vehicles exhausts show

some similarities on the chemical species presence in particulate matter sampled from Nibong Tebal and Parit Buntar. Factories also contribute particulate matter into the ambient air of Parit Buntar and Nibong Tebal. Particulate matters is emitted trough the stacks of the factories.

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PENERBITAN

A Study on Physical and Chemical Characteristics of Airborne Particulate Matter in a Developing Town in Northern Perak.

Abdul Haqi Ibrahim, Nor Azam Ramli and Wan Hashim Wan Ibrahim
School of Civil Engineering, Universiti Sains Malaysia, 14300 Nibong Tebal, Penang.

Abstract

This research investigates the physical and chemical properties of airborne particulate matters (PM) from Parit Buntar. Non-reactive carbon layer is glued onto a stub to collect airborne particulate matters from the atmosphere. The stub was exposed to the ambient atmosphere for 24 hours to allow the particulate matter to deposit onto it. PM sample from vehicles exhaust also being collected and analyzed in order to see the association between the vehicles as a source of particulate matter. The stubs then are placed directly into the Scanning Electron Microscope (SEM) to analyze their images. Chemical compositions of those particulate matters are being analyzed by using Energy Dispersive X-ray equipment that is presences as an accessory to the SEM. The electron microscope (SEM) used was a Leo Supra 50 VP while Energy Dispersive X-ray equipment used was Oxford Inca 400. From the research, it was found that the greatest contribution to particulate matters mass collected in Parit Buntar are carbon (organic carbon or/ and elemental carbon), O, Al, Si and other species such as Ca, K, Fe and Mg. These elements probably come from earth crust mineral and particles from vehicles exhaust as well as factories nearby. While the size is varies from 7.9 μm to 158 μm and can be categorized as coarse particles.

1.0 Introduction

Cities and towns are always being picture as abundant of populations, activities and materials. They therefore show the highest level of air pollution and being the largest target of impact. This phenomenon becomes worse with the presences of industrial areas around the town. Uncontrolled stacks emission from factories can also contribute to bad air quality to the town atmosphere. Construction activities, especially the dust from the construction sites and vehicles emission also play a role polluting the town atmosphere.

Air pollution is the important point of our concern because it affects people, ecosystem, plant, and building and monumental stones adversely. Air pollution can define as changed of air quality by addition of particles, gases, or energy forms (e.g., heat, radiation or noise) so that the altered atmosphere poses some harm (Godish, 1997).

In Malaysia, there are three main sources of air pollutants, mobile sources, stationary sources and open burning sources (Afroz *et al.*, 2001). These sources emit varies of air pollutants such as carbon monoxide (CO), sulphur dioxide (SO_2), particulate matters (PM) and etc. However, in Malaysia, five pollutants have been categorized as criteria pollutants and being monitor continuously. These five air pollutants are carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxides (NO_2), ozone (O_3) and particulate matter below than 10μm in size (PM_{10}) (DOE, 2002).

Health impact due to air pollution exposure can be divided into two categories, short-term and long-term effect. Short-term effects occur when the pollution level is very high and end with acute condition. However, long term effects are unknown and hard to trace. Some pollutants are carcinogenic and the effects appear only after a few years of exposure. The result also can be more serious for children, for whom the particulates inhaled relatively high to body size (Afroz *et al.*, 2001).

Researches have constantly demonstrated bad effects of particulate matter exposure on human health. The studies show that exposure to airborne particulate matter is connected with an increase incidence in both respiratory and cardiac disease. Although the affect of particulate matter to human health is given priority, the negative effects on plant, ecosystem, building and monumental stones should not be neglected.

During the haze episode back in September 1997, researchers found that particulate matter contributes most of the haze component compared to gases. During the hit, number of patient suffer to respiratory problem had increased. Example in Kuala Lumpur, patient came to get treatment because of respiratory problems increased from 250 to 800 per day while in Kuching, the number of patient increased two to three times during the peak time of smoke haze (Afroz *et al.*, 2001).

However, in this research, not all air pollutants being studied. Only particulate matter is given a consideration. Sample of particulate matters were collected and being analyzed to gain information of its chemical compositions and images. Research should be carried out intensively in order to build our knowledge in this area, thus give us more idea to handle this sort of problems. One of the great issues is whether the chemical or physical properties are important for its effect on health (Harrison and Yin, 2000).

2.0 Experiment

2.1 Particle sampling from area of interest

In this project, particulate matters from the ambient atmosphere of Parit Buntar was been studied. The following sampling methodology was carried out to collect sample from the atmosphere:

- Particles deposited on horizontal non-reactive surface (carbon layer) sheltered from rainfall. Figure 2.0 shows the non-reactive carbon layer that later being glued onto studs while Figure 2.1 shows the aluminium stubs.

Particles deposited on these carbon surfaces in a continuous way. These studs were exposed to the ambient atmosphere for 24 hours to allow the particulate matter to deposit onto it. The stubs were placed about 1.5 m from the land surface. Stubs that have been exposed to the atmosphere for 24 hour are then being stored in petri dish and ready to be analyzed.

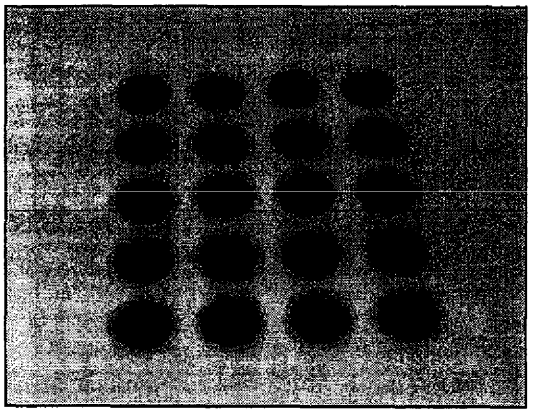


Figure 2.0: Non-reactive carbon layer.



Figure 2.1: Aluminium stud.

2.2 Sampling area

In Parit Buntar area, 10 locations have been identified to be the sampling location. Map of the towns were used to determine the sampling site that best represent the town area. Maps were provided by the local authority.

2.3 Sampling site categories

In order to do sampling, site of sampling are divided into two categories. Those categories are:

- Type 1: Urban site.

Locate stud in the central business district of the urban area on a congested, downtown street surrounded by buildings and having many pedestrians.

- Type 2: Suburban site.

Locate stud out of central business district of the urban area but quite close to major streets.

Table 2.0: Sampling sites locations in Parit Buntar.

PARIT BUNTAR	
URBAN SITE	RURAL SITE
Pusat Bandar (PUSAT BANDAR)	Kilang padi (KILANG PADI)
Pekan Lama (PEKAN LAMA)	Kompleks Sekolah (KOMPLEKS SEKOLAH)
Pekan Baru (PEKAN BARU)	Simpang Empat Taiping – Parit Buntar (SMPG4 TAIPING – PB)
Clock Tower (CLOCK TOWER)	Sempadan Perak – Pulau Pinang (PRK-PP)
Hotel Damai (HOTEL DAMAI)	Majlis Daerah Kerian (MDK)

2.4 Instrumental technique

X-ray mapping by SEM-EDX have been carried out in all the cases (particle bulk analysis)

The electron microscope (SEM) used was a Leo Supra 50 VP while Energy Dispersive X-ray equipment used was Oxford Inca 400. A scanning electron microscope (SEM) is used to observe the physical appearance and to record the digital images of the particles samples while EDX is use to analyze the chemical composition of the particulate matters. Before putting the samples into the SEM-EDX to be analyze, those samples were coated with Aurum (about 20 nm thick) by using sputter coater, Polaron SC 515.

3.0 Results

Table 3.0, shows the elements presence in the particles in table form. It is arranged in table manner to make it easier to identify the differences or similarities between the particles.

Table 3.0: Elements in particles collected in Parit Buntar

LOCATION	ELEMENTS													
	Al	Ca	Cl	Cu	Fe	K	Mg	Na	Si	S	Ti	C	O	Zr
KILANG PADI														
spot 1	*					*			*			*	*	
spot 2	*				*							*	*	
spot 3	*					*		*	*			*	*	
KOMPLEKS SEKOLAH														
spot 1	*				*	*	*		*			*	*	
spot 2	*				*			*	*			*	*	
spot 3	*	*	*		*		*	*	*	*		*	*	
PEKAN BARU														
spot 1	*				*				*			*	*	
spot 2				*	*				*	*	*		*	
spot 3	*				*	*		*	*			*	*	
PEKAN LAMA														
spot 1	*				*	*	*		*			*	*	

spot 2	*					*			*			*	*	
spot 3	*				*				*			*	*	
PUSAT BANDAR														
spot 1		*					*		*	*		*	*	
spot 2	*				*		*		*			*	*	
spot 3	*					*			*			*	*	
CLOCK TOWER														
spot 1	*	*							*			*	*	*
spot 2	*							*	*			*	*	
spot 3	*	*						*	*	*		*	*	
HOTEL DAMAI														
spot 1	*					*			*			*	*	
spot 2									*			*	*	
spot 3	*					*		*	*	*			*	
MDK														
spot 1	*	*				*			*			*	*	
spot 2	*				*		*		*			*	*	
spot 3	*								*			*	*	
PRK -PP														
spot 1					*				*	*	*	*	*	
spot 2			*		*							*	*	
spot 3	*				*	*	*		*			*	*	
SMPG4 TAIPING-PB														
spot 1	*				*		*		*			*	*	
spot 2	*								*			*	*	
spot 3	*				*				*			*	*	

* Element presents in particle

Table 3.1 shows the size of each particle that had been analyzed using Scanning Electron Microscope (SEM).

Table 3.1: Size of particles.

Samples from Parit Buntar	**Size (µm)**	**Samples from Nibong Tebal**	**Size (µm)**
KILANG PADI		SEK TRANS	
Spot 1	129	spot 1	14.1
Spot 2	114.5	spot 2	8.3
Spot 3	125.8	spot 3	7.9
PUSAT BANDAR		JAWI	
Spot 1	35.6	spot 1	53.3
Spot 2	33.3	spot 2	19.7
Spot 3	36.5	spot 3	4.8
PEKAN LAMA		PB. N TEBAL	
Spot 1	71.9	spot 1	19.4
Spot 2	42.6	spot 2	7.5
Spot 3	58.05	spot 3	7.5
PEKAN BARU		SG BAKAP	

Spot 1	49.5	spot 1	65
Spot 2	101.6	spot 2	8.9
Spot 3	38.13	spot 3	9
KOMPLEKS SEKOLAH		P. KELING	
Spot 1	23.07	spot 1	30.8
Spot 2	15.7	spot 2	10.4
Spot 3	13.8	spot 3	25.3
SMPG4 TAIPING-PB		MAYBANK NT	
Spot 1	72	spot 1	77.4
Spot 2	48.7	spot 2	33.5
Spot 3	35.2	spot 3	158.05
PRK-PP		SM TEKNIK	
Spot 1	58.8	spot 1	71.1
Spot 2	42.2	spot 2	77.4
Spot 3	91.7	spot 3	36.3
HOTEL DAMAI		TEPI SUNGAI	
Spot 1	106.5	spot 1	290.3
Spot 2	86.7	spot 2	77.4
Spot 3	38.1	spot 3	60.5
MDK		SM SRI NIBONG	
Spot 1	110	spot 1	25.9
Spot 2	82.2	spot 2	77.9
Spot 3	82.2	spot 3	222.6
CLOK TOWER		TELUK IPIL	
Spot 1	27.2	spot 1	75.5
Spot 2	94.45	spot 2	85.5
Spot 3	32	spot 3	74.1

4.0 Discussion

Before the research being carried out, the hypothesis is that there are heavy metal presences as a main element in the particulate samples collected in Parit Buntar and Nibong Tebal. However, after the research being carried out, heavy metals are not the main elements of the particulate.

Research by (Ye Wu *et al.*, 2003) mentioned that the greatest contribution of coarse paticles in urban and rural areas are organic carbon, elemental carbon, sulfate, nitrate, ammonium, Na, Cl and geological species such as Si, Ca, Al, Fe, K and Mg.

From the result obtained, it is believed that most of the partilces are from the earth crust. There are few points that make this statement make sense. The elements presence in all particles are closely same with the elements presence in the earth crust. There are 10 most abuntant elements in earth crust namedly oxygen, silicon, aluminium, iron, calsium, sodium, magnesium, potassium, titanium and hidrogen with the percentage of weigth 46.1%, 28.2%, 8.23%, 5.63%, 4.15%, 2.36%, 2.09%, 0.565% and 0.14% respectively.

Refer to the Table 3.0 and 3.1, 50 out of 60 samples contain Al and 55 out of 60 samples contain Si while O present in all samples. O is very reactive with other elements. O bond as an O^{2-} anion to form compound called oxides. Other crustal species as mentioned above also presence in the sampel randomly. Mineral which combine Si and O elements are called silicates, and combined they are the most abundant minerals on the Earth (Lutgens and Turbuck, 2000). This point gives strong evidence that most of these particles are silicate minerals. Those particles could be olivine $(Mg,Fe)_2SiO_4$, Augite $(Mg,Fe)SiO_3$, Hornblende $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$, Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$, Muskovite $KAl_2(AlSi_3O_{10})(OH)_2$, orthoclase $KAlSi_3O_8$, Plagioclase $(Ca,Na)AlSi_3O_8$ and quartz SiO_2. By looking to the empirical formula, it is possible that particles collected are probably silicate mineral. All elements can be seen present in the particles collected in Parit Buntar and Nibong Tebal.

At Kilang Padi sampling area, rice husk ash may also contribute particulate matter rich in Si content. Rice husk ash contains about 85 % Si. The size of rice husk is small, about 25 μm in diameter. This ash can be transported from the factory area to places nearby by with action (http:// ebigchina.com/ ebcps/4/pd/164663.html 6 April 2005).

Earth crust materials present in the air by certain action. Earth works at construction site contribute most of the presences of soil dust wind blown rock-derived material in the atmosphere. Dry surface and high wind speed tend to be favoured the suspension of these earth crust materials in the air. Construction work near the sampling site is one of the examples how crust material was introduced into the atmosphere. Construction site near Sek . Keb Transkerian is one of them.

Beside that these crust element also become resuspended due to the action of the wind turbulence induced by passing road traffic. Asphalt road pavement and concrete pavement contain crustal mineral as one of the component. Asphalt road contains quatz (SiO_2), calcite ($CaCO_3$), asphalt and iron oxide (FeO). Mean while concrete pavement is mixed of limestone aggregate ($CaCO_3$), iron oxide (FeO) and cement (Micron *et al.*, 1979).

Beside the crustal material, other components may contribute to the chemical element of those particles. Fine particles may attach to the particles and make up the chemical elements of the particle. Particulate matter from the exhaust vehicles are much finer compare to the crustal material presences in the atmosphere and it is possible to attach to the coarse particulate. Gong and Beaglehole (2000) found that Al, Ca and S present in the diesel particulate samples 100% of the time. It is well known that diesel fuel contains S. Element S found in petrol samples might arise from lubrication oil (Gong and Beaglehole, 2000). Six samples from Parit Buntar indicated the presence of S in the particulate matter. Studies of particulate matter emitted from all type of vehicles exhaust demonstrated the presence of S. This clearly shows vehicles are the main source of S that later contribute to element S in particulate matter samples collected in Parit Buntar.

Besides, as an abundant element is earth crust mineral, Fe also can be present into the atmosphere result of iron released into the atmosphere during high-temperature processes such as metal smelting industries (Merano *et al.*, 2004). They are generally

rounded and probably come from the combustion of fossil fuels. There are some are not rounded derived mainly from other industrial activities (Esbert *et al.*, 2000).

Samples collected in Komplek Sekolah showed the presences of Cl. Main source of chloride are sea spray even at location hundreds of kilometers from the coast (Harrison et al., 2000). It is possible that these chlorides rich particles were blown from the sea to this area. From the Figure 3.0, we can notice that Parit Buntar is located along the costal line. Hence, the possibility for the chloride to be transport to the locations is very high.

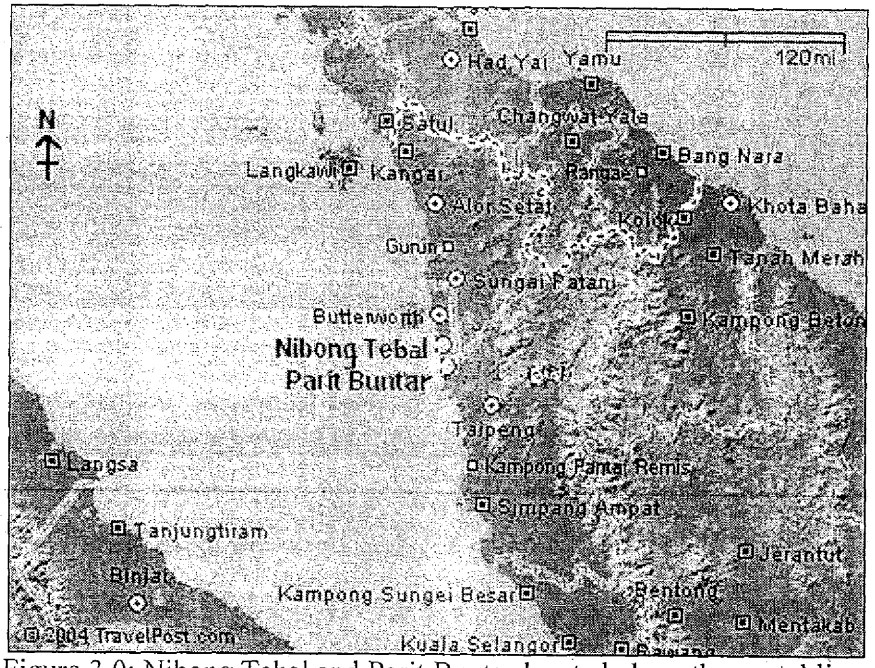


Figure 3.0: Nibong Tebal and Parit Buntar located along the costal line.

Particulate matter containing Cl is emitted from the industrial stacks in Parit Buntar and neighbouring Nibong Tebal dispersed by wind to Parit Buntar and its vicinity. Analysis of particulate matter samples collected from the palm oil mill also shows the occurrence of Cl element. There is a possibility that this particulate matter also being emitted to the Parit Buntar's atmosphere and the wind blow disperse the particulate matter to adjacent location.

Vehicles on road also produce particulate matter containing Cl element. Those species that presence in the particles also has close relationship with the chemical components of palm oil ash. It is believed that particulates also being emitted by the stack of palm oil mill located in the area of interest. Most species found in the particulates can be found in the fiber ash and shell ash of palm oil. Major components of fiber ash from boiler are SiO_2, K_2O, CaO, Al_2O_3, Fe_2O_3, MgO, P_2O_5, and SO_3 while major component of shell ash are SiO_2, K_2O, CaO, Al_2O_3, Fe_2O_3, MgO and P_2O_5, (Boon *et al.*, 1987)

55 spots of the particulate matter analyzed by EDX analyses showed the presence of carbon. It is believe that elemental carbon and/ or organic carbon come from biological particles (spores and pollens) as well as those particles produced by the

internal combustion of oil and petrol in vehicles. Such combustion produces organic compounds that condense in the air to form spherules smaller than 100 nm in diameter, this subsequently aggregate to form larger particles. Because of their small size and low density, these agglomerates can travel in air for long distances (Moreno *et al.*, 2004). All sample collected from six type of vehicles contain C element. This result support that C element is mainly contribution of vehicles regardless what the type is.

Sample from Pekan Baru and Sempadan Perak-Pulau Pinang contain Ti element. Ti is listed in ten most abundant elements in earth crust with 0.565% by weight. Sample from vehicles exhaust and palm oil mill are not showing any presence of Ti element. Hence, Ti might be come from the earth crust material or other sources such as brake dust produced by vehicle's brake system and also from the tyre dust (Adachi and Tainosho, 2004).

From the list of particle's size in Table 3.1, it shows that the particles are ranged from 7.9 μm to 158 μm. Particles in this range of size is grouped as a coarse paricles. Through the SEM images, shapes of those particulate collected can be divided into 2 group, circular and rod shape.

5.0 Conclusion

Chemical species components of particulate matters were measure near major roads, parks and background location in Parit Buntar and Nibong Tebal. The greatest contribution to total particulate matters are carbon (organic carbon or/and elemental carbon), Al, Si and O. K and Fe are two species that also frequently presence in the particles composition. Other species such as Ca, Cl, Cu, Mg, Na, Si, S, Ti, Zr, P and N are present randomly.

Particulate matter in Parit Buntar and Nibong Tebal can be categorized as coarse particles because of the size range. The sizes of the particles are from 7.9 μm to 158 μm. Particles sampled from Nibong Tebal and Parit Buntar can be group into two major different shape, rod shape and circular shape.

Crustal mineral had been identified as the main contributor to the most of the particulate matters in Parit Buntar and Nibong Tebal. Crustal materials are believed to be present due to wind blow on loose soil surfaces especially at a construction site. However, wind turbulence cause by vehicles moving fast on road also resuspended the road pavement dusts which contain crust mineral. Vehicles also emit particulate matter to the atmosphere. Analysis of particulate matter from vehicles exhausts show some similarities on the chemical species presence in particulate matter sampled from Nibong Tebal and Parit Buntar. Factories also contribute particulate matter into the ambient air of Parit Buntar and Nibong Tebal. Particulate matters is emitted trough the stacks of the factories.

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Research Paper

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Surfactants in South East Asian Aerosols

Mohd Talib Latif,[A,D,E] *Peter Brimblecombe*,[A] *Nor Azam Ramli*,[B] *Justin Sentian*,[C] *Jariya Sukhapan*,[A] *and Norela Sulaiman*[D]

[A] School of Environmental Sciences, University of East Anglia, NR4 7TJ Norwich, United Kingdom.

[B] School of Civil Engineering, USM, Engineering Campus, 14300 Nibong Tebal, Seberang Perai Selatan, P. Pinang, Malaysia.

[C] School of Science and Technology, Universiti Malaysia Sabah, LB 2079, 88999, Kota Kinabalu, Sabah, Malaysia.

[D] School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Malaysia.

[E] Corresponding author. Email: mohd.latif@uea.ac.uk

Environmental Context. *Surfactants are present in all atmospheric aerosols with potential effects on surface tension, cloud droplets and even human health. They appear to be anionic and associated with yellow aqueous extracts, suggesting a humic-like character. These surfactants are probably derived from the oxidation of combustion-generated soot (from vehicles and forest fires).*

Abstract. The concentration of surfactants in aerosols was determined at several sites in South East Asia, Bangi, Penang and Kota Kinabalu in Malaysia and Bangkok, Thailand, as methylene blue active substances (MBAS) and ethyl violet active substances (EVAS) for anionic surfactants and disulphine blue active substances (DBAS) for cationic surfactants. The methodology used is based on the formation of extractable ion-association complexes of surfactants and dye in organic solvents followed by spectrometric measurement of the intensity of the extracted coloured complex. Results showed surfactants in aerosols are mostly in the anionic form as MBAS and EVAS, and higher in aerosols collected in congested areas, especially in times of forest fires. Concentrations are in the range of 34.6 to 285.0 pmol m^{-3} for MBAS and 129.9 to 932.2 pmol m^{-3} for EVAS. Several different types of soot and humic acid seem possible sources of surfactants in atmospheric aerosols. Laboratory experiments suggested that combustion products, especially from motor vehicles, are important primary sources of surfactants in aerosols. There is also some laboratory evidence that there are secondary sources for these surfactants in aerosols, possibly humic-like substances (HULIS) from the oxidation and photochemical reaction of soots and humic acid.

Keywords. aerosols — humic substances — surfactants

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Introduction

Surfactants are a ubiquitous component of the atmospheric aerosol, with potential effects on surface tension, cloud droplets and perhaps even human health.[1–3] Monitoring data and studies on ambient air quality show that some of the air pollutants in large cities in South East Asia are increasing and not always at acceptable levels according to ambient air-quality standards. The three major sources of air pollution in these areas are mobile sources, stationary sources, and open-burning sources.[4]

South East Asia is also affected by regional air pollution episodes, especially haze derived from forest fire smoke. According to Abas et al.,[5,6] the haze phenomenon in 1991, 1994 and 1997 came from agricultural burning and changes of land use practice in some areas and was particularly exacerbated by El Niño drought periods in 1997. Biomass combustion is an important primary source of many trace substances that are reactants in atmospheric chemistry and of soot particulate matter, which decreases visibility and absorbed incident radiation. Chemically, biomass smoke particles contain thermally unaltered and partially altered biomarker compounds from the vegetation and can change climate by altering the radiation balance.[7] In urban atmospheres, particles collected in haze conditions are expected to be derived from both biomass combustion and vehicular emissions.

Surfactants are part of the water-soluble organic component of aerosols. Earlier work by Latif and Brimblecombe[8]

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has suggested that humic-like substances may contribute to the surface activity of atmospheric aerosols in addition to the lower molecular weight carboxylic acids often assigned this role.[8] Traditionally, humic materials were seen as relatively stable, polydisperse macromolecules that arise from the decay of the biota in the environment. Their water-soluble components, humic acid (HA) and fulvic acid (FA), are ubiquitous in both aquatic and terrestrial systems. They are products of the oxidative degradation, and subsequent polymerization, of plant and animal matter in the environment. In the atmosphere, humic-like substances (HULIS) are molecules of high molecular weight, carrying many functional groups.[9] However, although HULIS may be derived from wind-blown soil, it can also be a secondary product of the oxidation of soot particles, e.g. HULIS is produced when soot is exposed to ozone.[10] These oxidation processes generate oxygen-containing functional groups (often aromatic polyacids), increasing the polarity of soot surface, thus bringing about its 'solubility' and surface activity. They have been found to interact with a wide range of substances, including metals and organic pollutants. As a consequence of the detergent-like character of many humic materials, it was found that their interaction with hydrophobic organics often leads to solubilization.[11,12] Thus, there should be a connection between the biomass burning and the presence of HULIS in aerosol samples.

This study presents the concentration of surfactants in aerosols from several sites in South East Asia, namely Penang, Bangi and Kota Kinabalu in Malaysia and Bangkok in Thailand. The surfactants will be measured as methylene blue active substance (MBAS) and ethyl violet active substances (EVAS) for anionic forms and disulphine blue active substances (DBAS) for cationic forms. We also measured the concentration of surfactants in aerosols collected during a June–July 2004 haze episode in Malaysia. The study used laboratory experiments to evaluate several potential sources of surfactants in the atmosphere and the production of surfactants after exposure of combustion aerosols to natural air, ozone and light.

Experimental

Aerosol Sampling and Surfactant Analysis

Aerosol samples PM_{10} (particulate matter with diameter below 10 μm) were collected from several stations in Malaysia and Thailand, namely Universiti Kebangsaan Malaysia (UKM) in Bangi; Engineering Campus, Universiti Sains Malaysia (USM) in Penang and Universiti Malaysia Sabah (UMS) in Kota Kinabalu; total suspended solids (TSP) were collected at the Thailand Pollution Control Department station at Din Daeng, Bangkok. All sampling stations were located in areas that could be catagorized as urban or semi-urban. Aerosols were collected using a calibrated high-volume sampler equipped with pre-fired (at 500°C) fibreglass filter papers at a flow rate of 1 m^3 min^{-1} for 24 h. After sampling, the filters were carefully packed in aluminium foils (pre-fired as the filters), conditioned in a desiccator for 24 h before weighing and stored in a refrigerator (4°C) until analysis. Unused filter papers were kept as blanks to be subjected to similar analytical procedures.

Half of the filter papers with aerosol samples were also cut into 1 cm^2 squares and put into a new disposable centrifuge tube (Corning), and then 40 mL of ultra-pure water (Neptune Analytical 18.2 MΩ cm resistivity) was added. The mixture was sonicated for 45 min and then filtered through a 47-mm Whatman cellulose acetate filter (pore size 0.2 μm) under vacuum. The filtered solution was diluted to 100 mL with ultra-pure water in a volumetric flask and kept at 4°C. Surfactant analysis was carried out within a few days of extraction.

The surfactant determination was based on the formation of an ion-association complex between anionic or cationic surfactants and cationic or anionic dyes, followed by spectrophotometric measurement of the intensity of the extracted coloured complex. This methodology has previously been used for sea-spray samples by Oppo et al.[13] and cloud water by Cini et al.[14] The concentration of anionic surfactants was calculated from a calibration curve established with appropriate reference material such as sodium dodecyl sulfate (SDS) for anionic surfactants and zephiramine for cationic surfactants.[15] In our work, two dyes were used to determine anionic surfactants, namely methylene blue and ethyl violet, and disulphine blue dye was used to determine cationic surfactants. The details of the methodology were explained by Latif and Brimblecombe[8] and Sukhapan and Brimblecombe.[16]

Surface Tension Measurement

Surface tension analysis was carried out by the pendant drop method using a special needle to create a droplet from aerosol extracts. This classical method to determine surface tension has gained a new dimension with the rapid development of digital image and computer processing.[17] A digital camera (Pulnix TM500) was used in conjunction with a *Matrox Meteor* frame grabber and *Image-Pro Plus* (Media Cybernetics) software to determine surface tension based on droplet geometry. The blank for surface tension was set by using ultra-pure water with a surface tension value of 72 dyne cm^{-1}. The effect of surfactants on the aerosol extraction was measured by recording the value of the surface tension of the pendant drop every 5 s.

Ionic Concentrations and Colour of the Solution

The other half of the filters was used in an analysis for anions and cations in the aerosols. The cut filter papers were also sonicated, filtered and diluted to 100 mL in a volumetric flask. Anions, e.g. chloride, nitrate and sulfate, in the aerosol extract were determined using ion chromatography (Dionex 4000i ion chromatograph), whereas cations, e.g. potassium, magnesium and sodium, were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES; Varian Vista Pro).

The 'brown' colour absorbance of the extracts was measured using a Perkin Elmer UV/Vis spectrometer (Lamda 35) at 400 nm wavelength using ultra-pure water as a blank.

Surfactants in Extracts

Several possible sources of surfactants in atmosphere were explored starting with materials such as activated carbon (Kremer Pigmente), soot from wood (heating dried wood in iron retorts up to 275°C under anoxic condition), diesel soot and petrol soot (collected using a soft paint brush from vehicles exhausts) and commercial humic acid sodium salt (Aldrich Chemicals). Aqueous extracts were obtained from small quantities of each material (50 mg) extracted separately into 100 mL ultra-pure water in a volumetric flask. The extracts were filtered and treated as before.

Exposure of Materials to Ambient Air

A weighed quantity (50 mg) of dry activated carbon, soot from wood, diesel soot, petrol soot and sodium salt humic acid was exposed to summer outdoor air in a flask covered with aluminium foil. The air was passed over the sample using an air pump (1 L min^{-1}) for 1 h. The materials were then extracted with 100 mL of water filtered and treated as before.

Exposure of Particles to Ozone

Fifty milligrams of dry diesel soot, petrol soot and humic acid were exposed to ozone in a Dreschel bottle. The ozone was generated from pure oxygen in a laboratory ozonizer MX II in the fume cupboard. The

flow rate of ozone from the ozone generator was controlled at 1 L min^{-1}, which gave a concentration of ~20 mg L^{-1}. Extracts from these samples were filtered and treated as before.

Exposure of Humic Acid and Diesel Soot Solution to Ozone and Sunlight

A humic acid solution (0.1 g L^{-1}) and diesel and petrol soot suspension (0.5 g L^{-1}) were exposed to ozone (as described previously) in a Dreschel bottle for 1 h and for several hours to summer sunlight. Extracts from these samples were filtered and treated as before.

Results and Discussion

Surfactants in Atmosphere

Surfactant concentrations in atmospheric aerosols collected in Bangi, Penang, Kota Kinabalu and Bangkok are summarized in Table 1. The previous work has shown a reasonable relationship between aerosol MBAS and EVAS and surface tension.[8] Fig. 1 shows measurements of the surface tension of aerosol extract collected at UKM, Bangi and USM, Penang based on comparison with the surface tension of ultra-pure water (72 dyne cm^{-1}), indicating the presence of surfactants in the extract. The concentration of anionic surfactants in aerosols recorded at all stations was very high compared to cationic surfactants, which were at the detection limit. In Kota Kinabalu (on the campus of the University Malaysia Sabah adjacent to South China Sea), the low overall concentration of MBAS and EVAS is matched by low aerosol concentrations (pmol m^{-3} units). These quantities are both higher at Penang and Bangi. This suggest that some presence of surfactant is explained in terms of aerosol amount but not all, as revealed by the measurements showing the lower fraction of surfactant in the aerosol (μmol g^{-1}) at Kota Kinabalu. Sampling areas that were located in or near major cities, such as Penang, Bangi (near Kuala Lumpur) and Bangkok, were found to have higher concentrations of surfactants. The sampling station in Penang is located adjacent to a large paper mill as well as palm oil processing plants. In less polluted regions, the amount of surfactant in a given amount of aerosol is much decreased, in parallel with remote sites in the United Kingdom.[8]

The results from South East Asia also show that the concentration of surfactants analysed as EVAS in all stations always recorded at higher concentrations than those determined as MBAS. This trend was also found in samples collected at the University of East Anglia, Norwich using the same method.[16] The ethyl violet is sensitive to a wider range of molecules[18] and impurities that could account for the higher apparent concentrations measured using this dye.[8]

Surfactant concentrations in aerosol collected during the haze phenomenon in Malaysia at the end of June and in early July 2004 suggest that forest fires influenced the concentration of surfactants, especially when measured as MBAS

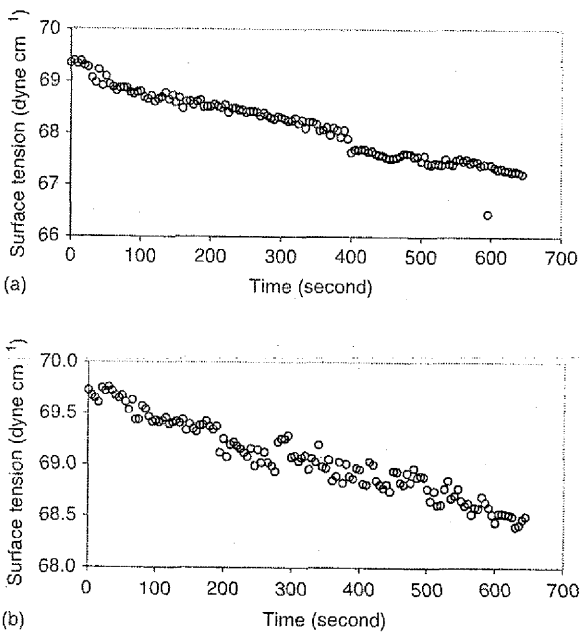


Fig. 1. The surface tension of a droplet of aerosol extract. This changes as the droplet gets smaller and the surface tension decreases.[8]

Table 1. Concentration of aerosol (median) and surfactant (MBAS, EVAS and DBAS) from several stations
Values in the parentheses show the range of surfactant concentrations (maximum–minimum) in aerosols

Station	Aerosol concentration		MBAS		EVAS	DBAS	
	(μg m^{-3})	(pmol m^{-3})	(μmol g^{-1})	(pmol m^{-3})	(μmol g^{-1})	(pmol m^{-3})	(μmol g^{-1})
USM, Penang (PM_{10})	48.3	168.7	4.7	505.0	13.6	5.7	0.15
	(26.3–73.5)	(73.5–378.0)	(1.1–6.7)	(338.0–660.0)	(4.6–18.1)	(1.3–12.0)	(0.03–0.30)
UKM, Bangi (PM_{10})	71.1	176.3	2.5	932.2	12.6	3.8	0.06
	(34.4–97.8)	(111.0–287.0)	(2.1–3.4)	(681.0–3576.0)	(10.4–39.0)	(0.0–11.4)	(0.00–0.16)
UMS, KotaKinabalu (PM_{10})	26.1	34.6	1.7	130.0	6.4	1.4	0.06
	(6.0–54.5)	(21.8–81.3)	(0.5–5.5)	(61.3–332.5)	(2.1–19.4)	(0.0–3.1)	(0.00–0.13)
Din Daeng, Bangkok (TSP)	–	285.0	1.1	812.0	3.0	–	–
		(240.0–434.0)	(0.9–1.8)	(654.0–975.0)	(2.6–3.9)		
	–	141.0	2.1	451.0	6.1	–	–
		(138.0–185.0)	(1.8–2.3)	(444.0–494.0)	(5.6–7.4)		

PM_{10}, particulate matter with diameter below 10 μm; TSP, total suspended solids. MBAS, methylene blue active substances; EVAS, ethyl violet active substances; DBAS, disulphine blue active substances.

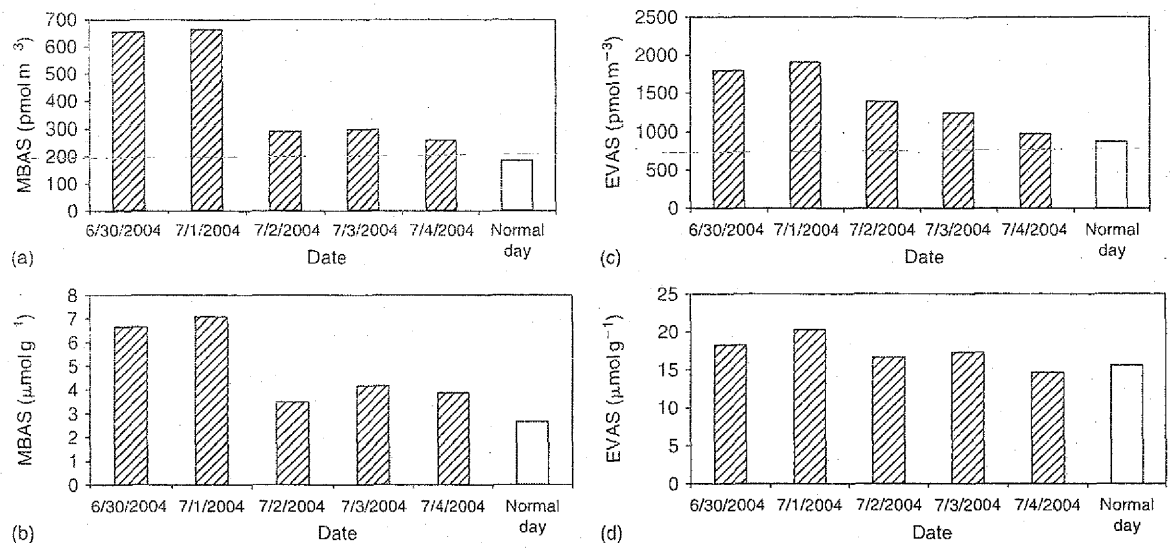


Fig. 2. The concentration of methylene blue active substances (MBAS; a and b) and ethyl violet active substances (EVAS; c and d) in pmol m^{-3} and μmol g^{-1} during haze phenomenon (hatched) compared with normal day (clear) in Bangi, Malaysia.

(Fig. 2a,b). There are several possible sources of surfactants during periods of forest-fire haze. The obvious source seems to be the particles from distant areas of biomass burning or their photochemical and oxidation products. This is especially likely for Bangi, which is located in a semi-urban area and just 20 km south of Kuala Lumpur. The local sources of pollutants may be readily enhanced by moderate winds and a dry-season inversion that traps the smoke plume.[4] Awang[19] showed, in the case of air quality in Malaysia, that the highest level of non-biomass burning during the haze phenomenon was found in Petaling Jaya, which is also located near Kuala Lumpur. Based on these studies, the surfactants in atmospheric aerosols collected during the haze phenomenon in this study seem to have arisen from the combined effects of biomass burning and anthropogenic local sources.

Correlation with Anions and Cations

The correlation of MBAS in aerosol from Bangi, Penang and Kota Kinabalu, Malaysia, with anions such as nitrate, sulfate and chloride, is shown in Fig. 3a,b,c. Results indicate that the correlation of MBAS was better with nitrate ($n = 32$, $r = 0.83$, $P < 0.05$) and sulfate ($n = 32$, $r = 0.73$, $P < 0.05$) compared with chloride ($n = 32, r = 0.53, P > 0.05$). The correlation of EVAS and these three anions also indicated the same results with an r-value of 0.65, 0.77 and 0.45 for nitrate, sulfate and chloride respectively. Nitrate and sulfate are often higher in aerosol collected from urban areas.[20] It is also suggested that human activities, such as combustion from motor vehicles, industrial activities and open burning, may influence the concentration of surfactants in South East Asia more than natural sources, such as the sea surface microlayer, which would likely correlate with chloride. Correlation between MBAS and cations (Na^+, K^+ and Mg^{2+}) (Fig. 4) shows a significant correlation with potassium ($n = 30$, $r = 0.74$, $P < 0.05$) and magnesium ($n = 32, r = 0.74, P < 0.05$), which may be an indication of several possible sources such as biomass burning (K^+) and soil dust (Mg^{2+}).[21,22] However, a relation to sodium remains, which could indicate a contribution of surfactant from the sea surface (c), as suggested by researchers such as Blanchard,[23] Gill et al.[24] and Tervahattu et al.[25,26]

Possible Sources of Surfactant in Atmosphere

Laboratory measurements have been used to reveal potential sources of atmospheric surfactants. The concentrations of MBAS and EVAS measured in diesel soot, petrol soot, soot from wood and activated carbon as a reference are listed in Table 2. These substances were chosen to represent the contribution to aerosol surfactant in South East Asia, most particularly motor vehicle particles and biomass burning. Results from the laboratory work showed that diesel soot from motor vehicles had the highest concentration of anionic surfactant determined (Table 2). Thus, in urban areas this would suggest that diesel soot can make a large contribution to the surfactant load of aerosols. However, even though diesel has a relatively high concentration of MBAS (i.e. 1.9 μmol g^{-1}), it is insufficient to explain the even higher concentrations of MBAS found in urban aerosol (e.g. Penang 4.7 μmol g^{-1}). This may be indicative of the production of surfactants in the atmosphere, because other potential sources such as humic acid and soot from wood indicated a much lower contribution to aerosol surfactants.

Soot, especially from diesel engines, is rich in organic carbon, which can lead to the formation of surfactants by oxidation processes perhaps through the formation of polar surface groups such as carboxylates.[27,28] These products, particularly where they are of high molecular weights, could well be related to HULIS. This seems reasonable given that humic substances are known to be surfactants. They are typically yellow through to brown in the environment (*sic.* the German *gelbstoffe* of marine systems). Our measurements show a relationship between absorbance of the brown colour

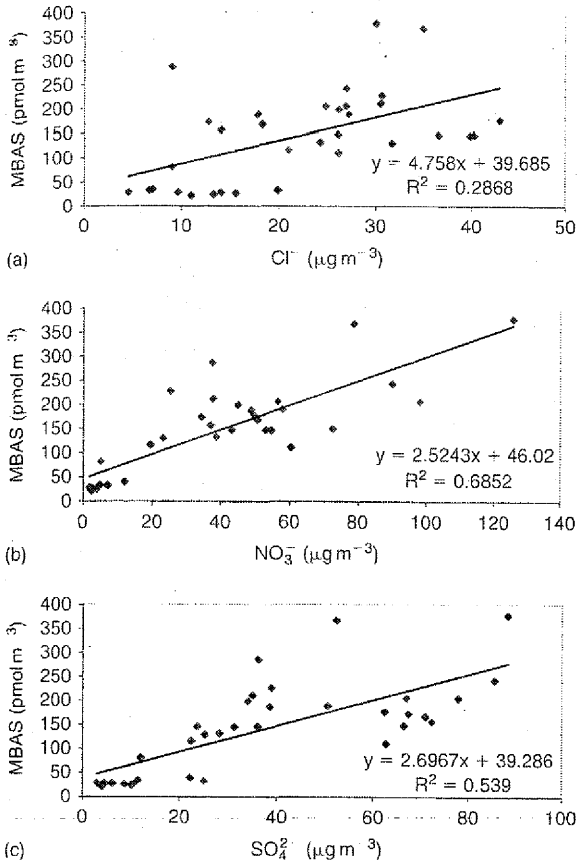


Fig. 3. The concentration of methylene blue active substances (MBAS) from Bangi, Penang and Kota Kinabalu compared with the anion concentration.

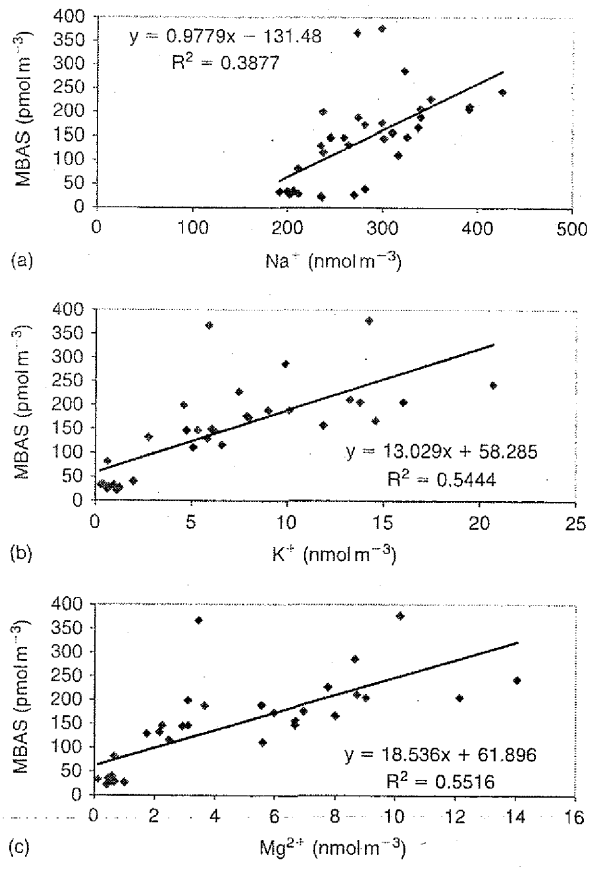


Fig. 4. The concentration of methylene blue active substances (MBAS) from Bangi, Penang and Kota Kinabalu compared with the cation concentration.

Table 2. The average concentration of possible sources of methylene blue active substances (MBAS) and ethyl violet active substances (EVAS) in atmospheric aerosols

Substances	Concentration (μmol g⁻¹)	
	MBAS	EVAS
Humic acid	0.52 ± 0.08	0.50 ± 0.03
Diesel soot	1.99 ± 0.04	9.83 ± 0.25
Petrol soot	0.65 ± 0.04	0.81 ± 0.06
Soot from dry wood	0.22 ± 0.01	0.10 ± 0.02
Activated carbon	0.17 ± 0.01	0.26 ± 0.02

of aerosol extract (at 400 nm) and the concentration of MBAS and EVAS (Fig. 5a,b).

Effect of Sunlight, Ambient Air and Ozone

The weather in South East Asia includes both dry and wet periods, but much sunlight for the whole year. These physical conditions may influence the chemical reactions on aerosols. In this study, we exposed activated carbon, soots and humic acid to natural air, ozone and sunlight to determine any increase in surfactant concentration. Results of these experiments showed that the concentration of MBAS

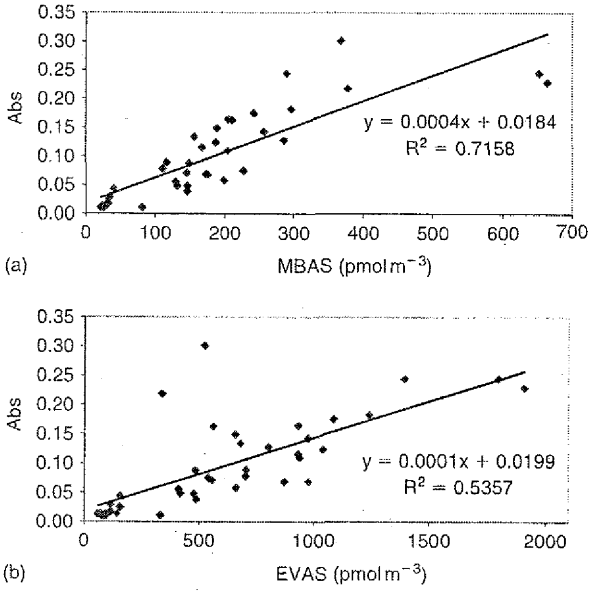


Fig. 5. Absorbance of aerosol extract at 400 nm as a function of methylene blue active substances (MBAS) and ethyl violet active substances (EVAS) concentration.

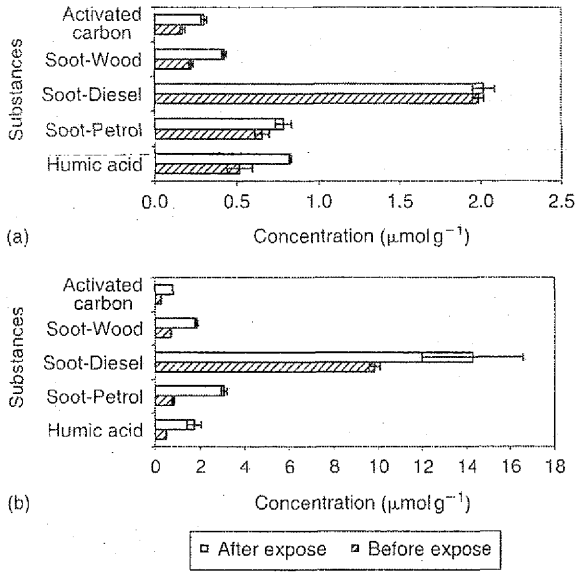


Fig. 6. The concentration of (a) methylene blue active substances (MBAS) and (b) ethyl violet active substances (EVAS) in activated carbon, soots from wood, diesel, petrol and humic acid after exposure to ambient air.

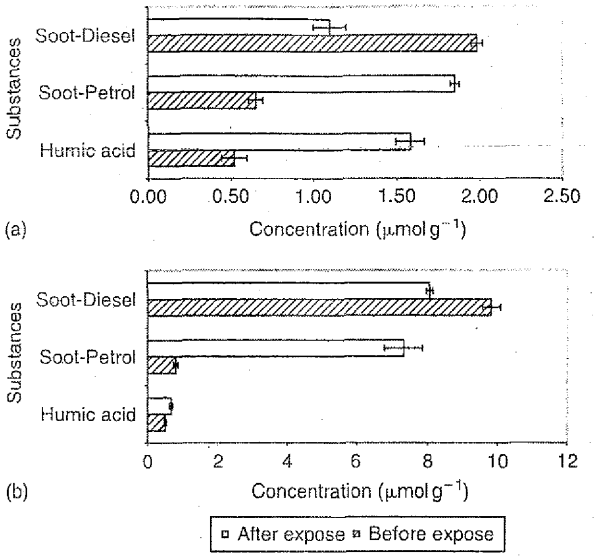


Fig. 7. The concentration of (a) methylene blue active substances (MBAS) and (b) ethyl violet active substances (EVAS) in soots from wood, diesel and petrol and after exposure to ozone for 1 h.

and EVAS in dry activated carbon, soots and humic acid increased after exposure to afternoon summer air (Fig. 6a,b), suggesting that surfactants were either present in the air, or produced on the surface. The high molecular weight of typical surfactants favours the latter suggestion. Exposure to ozone (Fig. 7a,b) showed that the concentration of surfactant in humic acid solution increased, but decreased in diesel soot extract, which indicates that ozone has the capability to induce both the formation and destruction of surfactants on aerosols. Experiments with humic acid solution showed that the concentrations of MBAS and EVAS increase for the first hour of ozone exposure before decreasing to almost the original level (Fig. 8). This may suggest that the surfactants are generated from the oxidation of high molecular weight substances, but can be destroyed after further exposure.

Results from exposure to light show that the concentration of surfactants in humic acid solution increased after it was exposed to natural summer sunlight (Fig. 9). The brown colour of the humic acid became yellow after exposed to light. Repetition of the same experiment with the addition of natural air exposure showed the same trends where the concentration of surfactant was increasing.

Our experimental results support earlier findings by Decesari et al.,[10] showing that the oxidation of soot particles causes them to become more hydrophilic and acidic. The water-soluble organic compounds produced during this oxidation increase rapidly with ozone exposure. Oxidation processes generate oxygen-containing functional groups, increasing the polarity of soot surface, thus bringing about its 'solubility' and possibly making it resemble humic acid. Further evidence of the connection between the biomass burning and the presence of HULIS in aerosol sample was presented by Mayol-Bracero et al.,[29] who suggest that HULIS detected

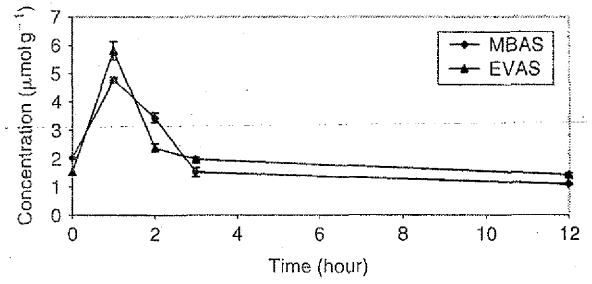


Fig. 8. The comparison between the concentration of methylene blue active substances (MBAS) and ethyl violet active substances (EVAS) from humic acid solution (0.1 g L^{-1}) after exposure to ozone.

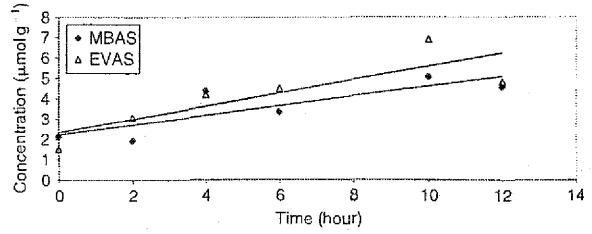


Fig. 9. The concentration of methylene blue active substances (MBAS) and ethyl violet active substances (EVAS) in humic acid solution (0.1 g L^{-1}) after exposure to natural sunlight (12 h).

in aerosol samples are not only oxidized primary compounds produced by combustion of biomasses, but they can also be derived from the reaction of soot particles with atmospheric oxidants. This would mean that water-soluble organic substances are formed from a complex series of processes and are a mixture of primary and secondary products.[10] In the upper troposphere, the reaction between soot and ozone could

decrease the concentration of ozone, increase solar radiation and affect the reaction chemistry.[28]

Conclusions

The concentration of surfactants in atmospheric aerosols collected from South East Asia was mostly anionic and found to be higher in aerosol collected from congested areas. Motor vehicles, especially with those with a diesel engine, seem important contributors. In less polluted regions of South East Asia, the concentration of surfactant in a given amount of aerosol is much decreased, in parallel with remote sites in the United Kingdom. Comparison of surfactant collected in haze conditions on normal days showed that the concentration of surfactants in aerosols was higher than that at other times, even when expressed in terms of the total mass of aerosol. Thus, the high concentration of particles produced in biomass burning did not reduce the concentration of surfactant in the aerosol, suggesting that the haze particles also contain surfactants. Diesel soot contains more surfactants than the other substances analysed and hints that in urban areas this may be an important source. However, conditions (sunlight or ozone) that encourage the oxidation of soot or humic-like materials have the ability to increase surfactant concentration in atmospheric aerosols.

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AIR POLLUTION EMISSION CONTROL OF A CRUDE PALM OIL FACTORY

Nor Azam Ramli and Lim Seang Joo
School of Civil Engineering, USM Engineering Campus,
14300 Nibong Tebal, Pulau Pinang
ceazam@eng.usm.my

ABSTRACT:

By end of 2003, 42% of the 370 Malaysia CPO factories in operation have been operating for more than 23 years, and another 26% operated for 13 to 22 years. A good proportion of these 68% or 252 CPO factories, when not well operated, would have its ***boiler*** and ***low temperature incinerator*** as two major sources of air pollution. This paper presented research carried out at a CPO factory that has been in operation for more than 25 years. Some new reference information is presented with focus on its fireman's operating method, especially on poor and good Forced Draft (FD) air control vs output variables of smoke opacity, stack particulate and gaseous emission.

Keyword: Crude Palm Oil Factory, Boilers, Forced Draft, Empty Fruit Bunch.

INTRODUCTION

Crude palm oil (CPO) factories, or commonly known as crude palm oil mills, have high tendency to pollute the environment. Emissions from factory's incinerator and boiler can cause air pollution. Air pollution emitted from older CPO factory which use 'non-automated' boiler and natural draft "incinerator" (or more appropriately, a kiln) is higher compared to the newer.

Palm oil production is Malaysia's number one agricultural industry, which achieved more than 13 million tonne crude palm oil output and revenue of more than RM7billion in year 2003. As a result, total solid waste generated in year 2003 was more than 27 million tonnes. Its breakdown consists of more than 14.9 million tonnes of Empty Fruit Bunch, EFB, more than 8.7 million tonnes of fibre, and more than 3.5 million tonnes of shell (DOE, 1999). The status of air quality in Malaysia in year 2003 was good to moderate most of the time. However, several unhealthy air quality instances were also recorded, especially in major cities.

Lim (2000, 2003) emphasised the importance of utilising palm oil mill's solid waste, Empty Fruit Bunch, EFB and the need to protect the environment that:

a) "the Prime Minister has recently reiterated the importance of alternative energy resources. In this regard, vast quantities of empty bunches which are currently under utilised have the potential to generate electrical energy with some pre treatment."
b) "... quality practice in consonant with environmental friendliness. In this regard, I would like to advise all palm oil mills to include in their planning, measures to ensure a cleaner environment which, in my opinion, strongly bears on our obligation to society....It is better to do it now than

face the closure of the mill by the DOE or face problems in the global market later."

Number of Crude Palm Oil Factories in Malaysia: The number of factories has increased close to triple from 131 in 1978 to 370 in 2003. By end of 2003, 42% of the 370 Malaysia's CPO factories in operation have been operating for more than 23 years. And another 26% operated for 13 to 22 years. Thus total of 68% or 252 CPO factories have been in operation for more than 13 years (Kamaruddin, 2003).

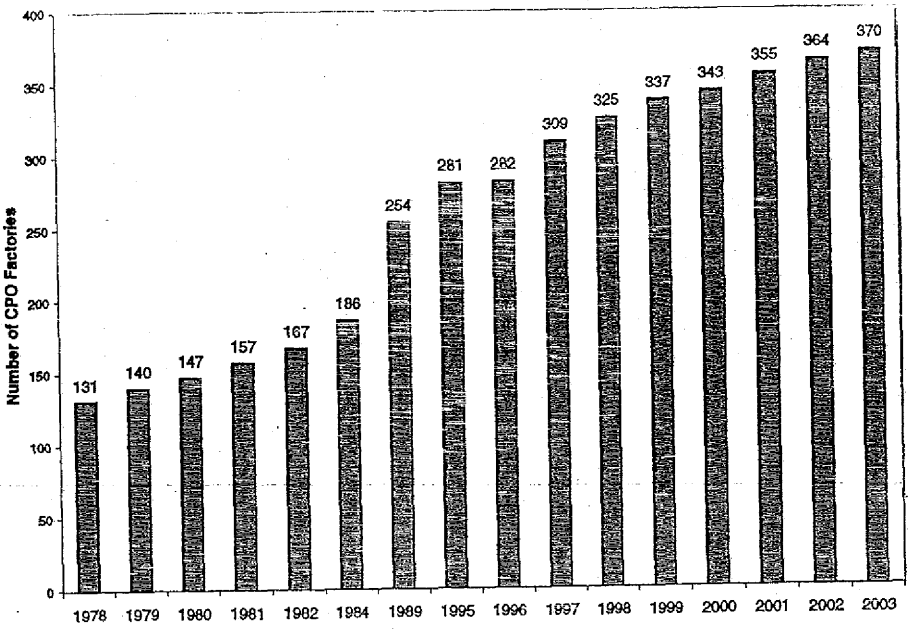


Figure 1: Malaysia's CPO Factories from 1978 to 2003

Changes in Land Use: In this era of industrialisation to attain Vision 2020, agricultural land is being gradually converted to development of building highway, roads, industrial manufacturing parks, housing schemes, commercial area, higher learning institutions and other developments. These developments encroach into oil palm plantations and crude palm oil factories. Those single factory proprietor and those 1 to 2 factories holding company would feel greater need to ensure the necessary pollution abatement equipment are installed, maintained well and function normally. The 42% of factories operating for more than 23 years would feel more pressure than newer factories as replacing old equipment are disruptive to operation.

The Environmental Quality (Clean Air) Regulation 1978: Malaysia's Environmental Quality (Clean Air) Regulation 1978 stipulates that Part IV Dark Smoke's section 14 for new facilities as of 1st Oct 1978 stipulates that smoke emissions of ***any colour*** comply to less than or equal to Ringelmann Chart 1 for non solid fuel and less than or equal to Ringelmann Chart 2 for solid fuel. Part IV Dark Smoke's section 15 for existing facilities before 1st Oct 1978 must comply by 1st April 1979 stipulates that smoke emissions of any colour comply to less than or equal to Ringelmann Chart 2 for non solid and solid fuel. Part IV Dark Smoke's section 16 allows smoke emission exception of less than 5 mins/hour provided total of less than or equal to 15 minutes per 24hours. Part V Air Impurities' section 21

stipulates that new facility as of 1st Oct 1978 complies std C; whereas old facility complies std B by 1st Oct 1981 after meeting section 22's requirement. Part V Air Impurities' section 25 stipulates that solid particulate/soot etc at emission point for std B be less than or equal to 0.5g/Nm^3, std C be less than or equal to 0.4g/Nm^3 Part V Air Impurities' section 27 Gaseous Substance does NOT mention CO's limit under substance emitted.

Part V Air Impurities' section 33 (Abatement of offensive odours), section 35 (Unburned waste and ash from incinerator), section 42 (Occupier to test and record) and section 43 (sampling point) stipulate these various requirements. Apart from this Clean Air Regulation 1978, Recommended Malaysia Air Quality Guideline, RMG for ambient air requires that the particulate of size 10 micron and below, PM_{10} be less than or equal to 150 µg/m^3 for 24 hours and carbon monoxide, CO be less than or equal to 10,000 µg/m^3 for 8 hours

In practice, compliance of the boiler's stack emission for those non-automated control and poorly maintained boiler would likely not meet Part IV section 16 of Clean Air Regulation 1978. The routine stack monitoring by 3rd party consultants for particulate emission is not representative as monitoring is often done during a period of good steady state to meet compliance.

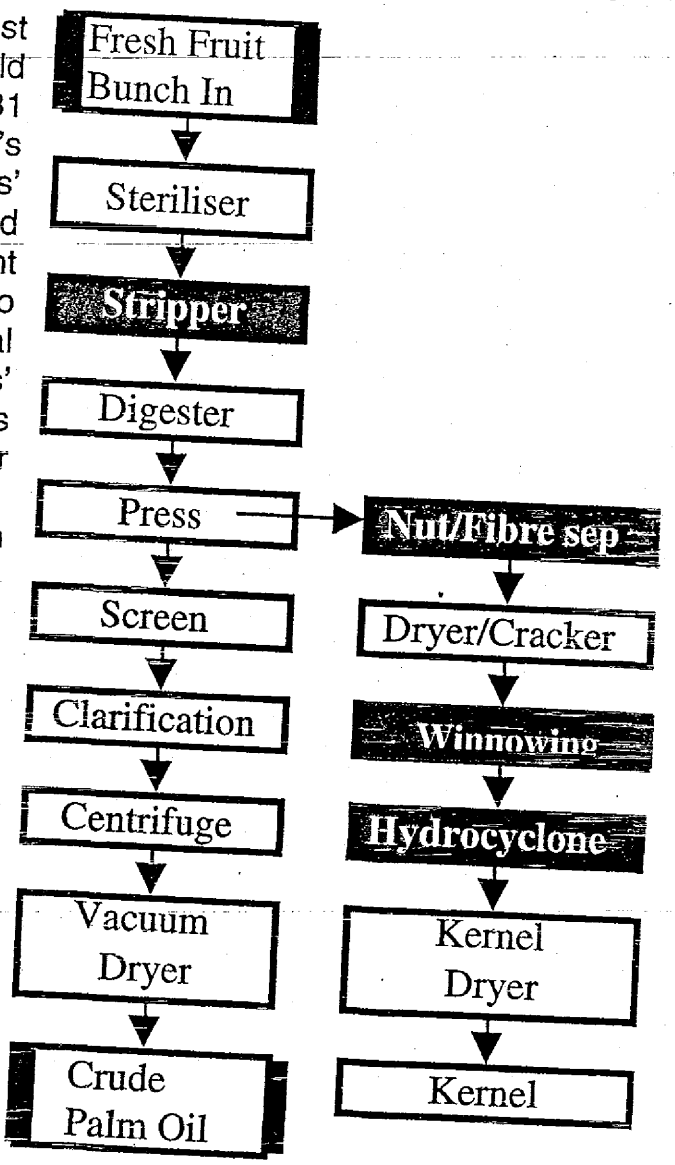


Figure 2: Flow diagram of a typical CPO mill processes.

The full Crude Palm Oil process (DOE, 1999) is shown in Figure 2. This process flow illustrates the full process flow of crude palm oil process. Of importance to this research are the processes related to stripper, nut/fibre separation, winnowing and hydrocyclone.

Fresh fruit bunches having being stripped will be converted to the press cake. Then, strong air current induced by suction fan separates the fibre from the nuts. Additional fibre is removed from the nuts in the rotating drum. These fibres have moisture of about 35% to 40%. 13.5% FFB by weight becomes by-products as fibre (DOE, 1999). Thirdly, the winnowing column separates out dirt and light shell from the cracked mixture. Further process using either hydrocyclone or clay suspension, using principle of difference in specific gravity of kernel, shell and clay suspension, separates out shell from the kernel. Shell from the winnowing column

has moisture of about 12% to 14% while those from the hydrocyclone has about 20% moisture. 5.5% FFB by weight becomes by-products as shell (*DOE, 1999*).

Sources of Air Pollution from a Crude Palm Oil Factory: Two major sources are from the boiler and incinerator/kiln. The boiler, burning solid fuel (palm fibre and palm shell), has tendency to emit black smoke and carbon monoxide as major air pollution constituents (plate 3). The incinerator (plate 4) burns the empty fruit bunches, emitting thick white smoke with oily smell. Although it is called incinerator, it is rather misleading, as it is not high temperature type. It is simply a kiln and burns the EFB using natural draft.

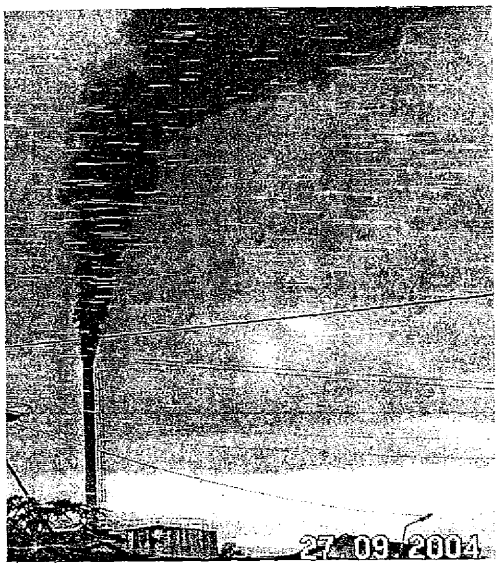


Plate 3: A CPO factory boiler emittingblack smoke

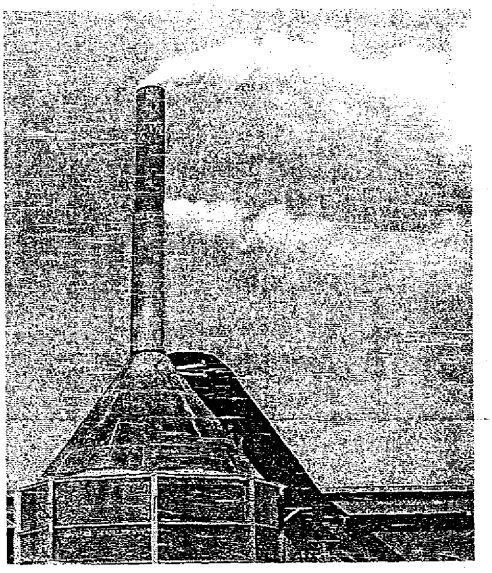


Plate 4: A CPO factory's incinerator/kiln

THE RESEARCH

In this research study, lengthy observation was made to understand on how the boiler and incinerator were operated, including start up, sustaining and cool down. Interview and discussion was also made with the 4 fire men, 3 boiler men and 1 mill engineer to understand their know how. The working condition in the factory is deplorable, as dust and noise are way above occupational safety limit. None of the 8 people that work on the boiler wear any eye, nose and ear personal protective equipment, PPE.

Current Situation at the Factory: Existing boiler in this max 30-tonne/day (operate at 20 tonne/day) has been used for 20 years. Boiler is Water Tube Boiler Model H425, made by Yoshimine Boiler Industry Co. Ltd. It uses fibre and shell as fuel. Most of the boiler instrumentation is already not in working order. The fuel is supplied to the boiler furnace using a screw conveyor. Normally, dry fibre and dry shell are automatically supplied, without any weight/mix control. When there's a short supply, manual addition of wetter fibre and shell are added to the ladder conveyor that supplies to the screw conveyor.

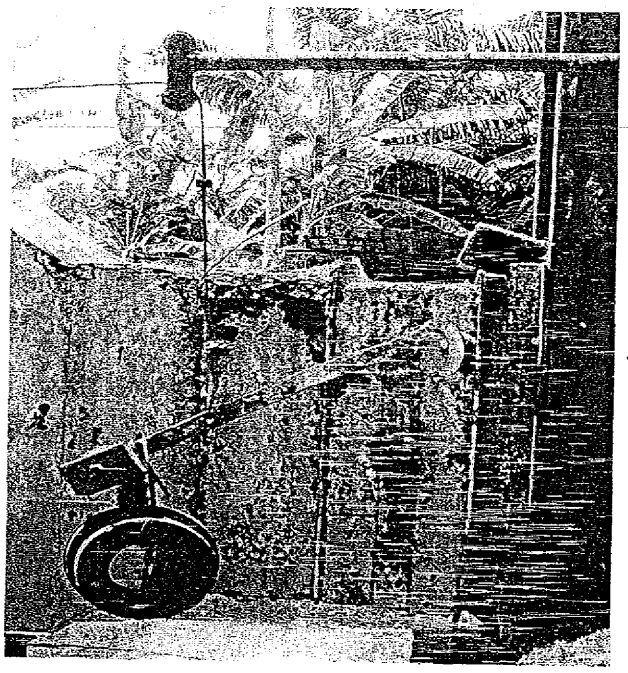


Plate 5: FD Damper Indicator Bar

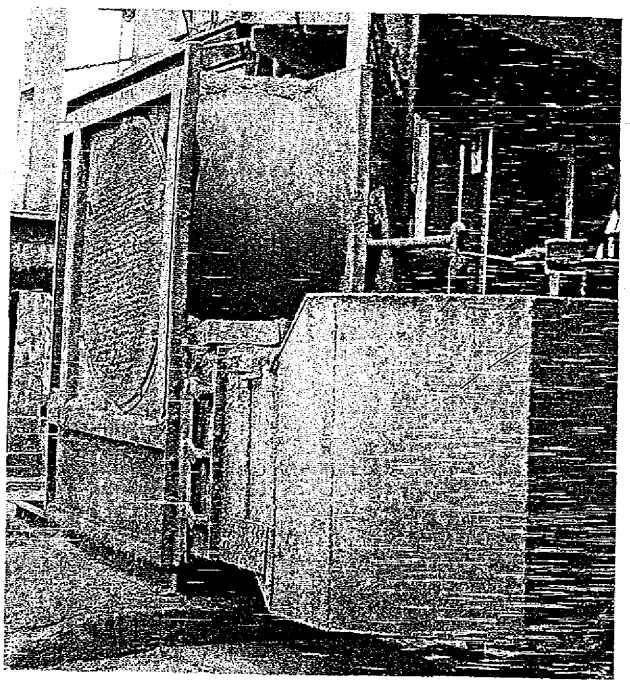


Plate 6: FD Fan and Damper Unit

Apart from SVO opens problem, the firemen also have tendency to stir the fire with the FD damper wide open at about physically 50 deg. This will cause more fly ash and also at times, black smoke. The other observation made is the supply of fuel can be erratic, at times too abundance, and at times, run out of fuel supply. This itself creates difficulty in controlling the combustion.

As for the incinerator, it was observed that with two strippers running, the EFB supply rate/min is between 25 to 40 pieces, thus averaging about 33 pieces/min. This equates to 33 x 4.2kg = 138kg/min. This means, about 8,280kg/hour of EFB are dropped into the incinerator. At this rate with the EFB of 60% water content, this big amount of fuel load, under natural draft condition, would simply just simmer and burn slowly, thus emitting heavy whitish-grey smoke.

Improvements: Several improvements proposal were conceived after investigating the factory and interviews. Using the 4Ms (Man, Machine, Method and Material) approach, and the constraint of not feasible to use any capital-intensive equipment (e.g. electrostatic precipitator for dust de-duster), most probable causes improvement can be made in Man and Method for the boiler operation.

a) Man – the 4 firemen and 3 boiler men each have more than 15 years of experience manning the boiler. Working under the adverse condition of dust and noise, they only desire to repeat their daily task of keeping the steam pressure from 220 to 250 psig, which causes the SVO to happen. Higher steam pressure means keeping the turbine generator running smoothly and the steriliser pressure maintained greater than 35psig. The turbine generator generates about 55% to 60% of the total 450kwH consumed. In doing so, they need more training to understand better the

negative impact on environment if their boiler operation method is not optimised.

b) Method – The operation method of the boiler can be modified to determine if improvement can be brought about:
   i) Operate the boiler at 220 psig, range from 205 to 235 psig
   ii) Install a vertical linear scale ruler to guide the operator on how much they have adjusted the FD damper turn wheel
   iii) Each adjustment of FD damper is limited to physical 5 deg (equal to linear scale of 2 divisions)
   iv) Stir the fire only when the FD damper is about physically 40 deg open.

Improvements Results: Using the standard boiler operation method, its smoke opacity readings, FD damper position and any other activities performed on the boiler were recorded. This observation and data collection was repeated on a different day. Then, using modified operation incorporating the above ideas, again its opacity readings were recorded, together with the associated boiler activities. During stack sampling, 2 runs were tested; one for the standard normal operation and one for the modified operation, incorporating all the 4 improved ideas as mentioned above. Each run lasted for about 45 mins. Equipment used are Durham Inc.'s 800-Stack-5 C-5000 Source Sampler for particulate, MRU Vario Plus Air Emission Monitor System for gaseous CO, NO_2 and SO_2.

The Boiler Smoke Opacity: When the boiler was operated under normal standard condition as practised by the 4 Fire men and 3 Boiler men, the smoke opacity readings, boiler pressure and the FD damper linear position was recorded on two days for total of about 5 hours of operation. Results in Figure 3 - Figure 5 showed numerous occasion of the boiler pressure reaching 250 psig and caused the Safety Valve to Open (SVO). These results in lost of steam energy and about 30 deg swing in FD damper. In such instance, surge of air will cause turbulence. Besides, chamber fire was also stirred while FD damper is at physically greater than 50 deg open.

Smoke opacity readings tend to go past 40% RC if the chamber fire is stirred at high FD damper position or when fuel supply is not consistent and additional top up with wetter fibre and shell is needed. But a big swing of FD damper by 30 deg might also result in greater than 40% RC, Figure 6. With modified operation using 5 deg FD damper for each adjustment, operate boiler pressure 15psig lower than normal operation and stir fire at FD damper less than 45 deg open, the smoke opacity and boiler pressure data are on Figure 7 and 8. Except on one occasion when FD damper was adjusted for testing that resulted in SVO, otherwise all others were below 250 psig. The smoke opacity also stayed below 40% RC during the 2 hours operation.

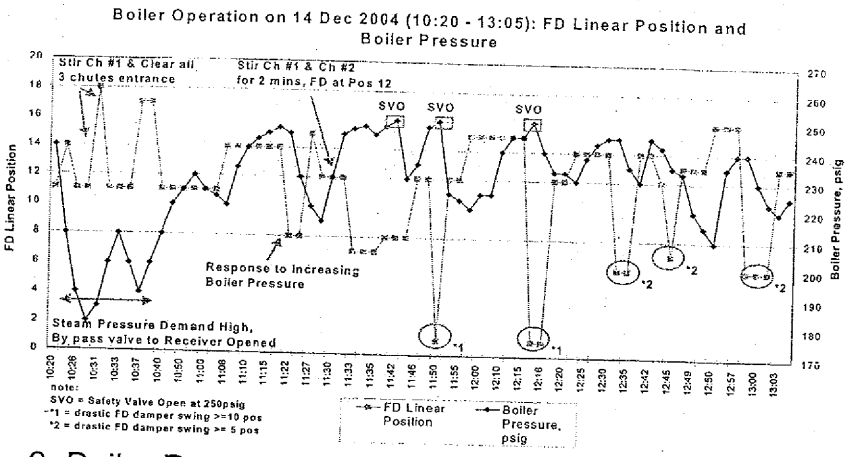


Figure 3. Boiler Pressure and FD Linear Position, standard normal operation.

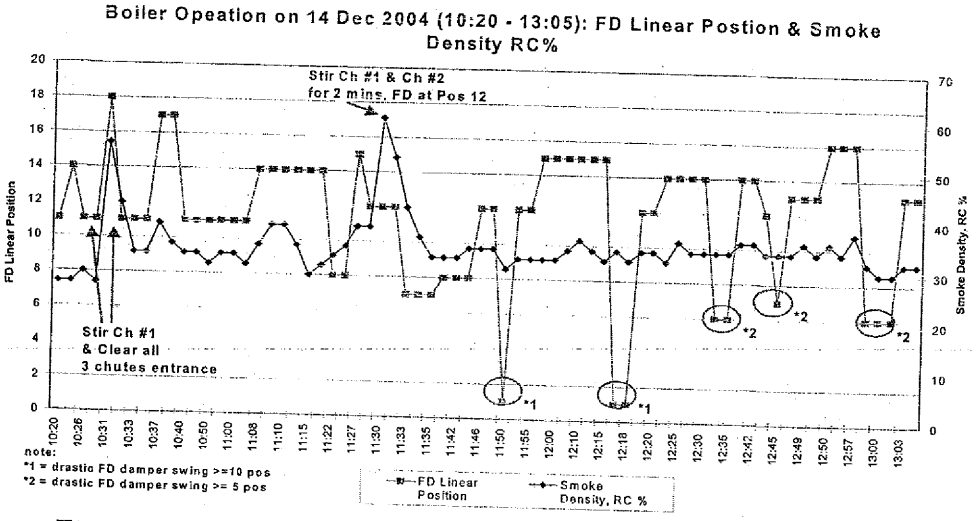


Figure 4. Boiler Pressure and FD Linear Position, standard normal operation.

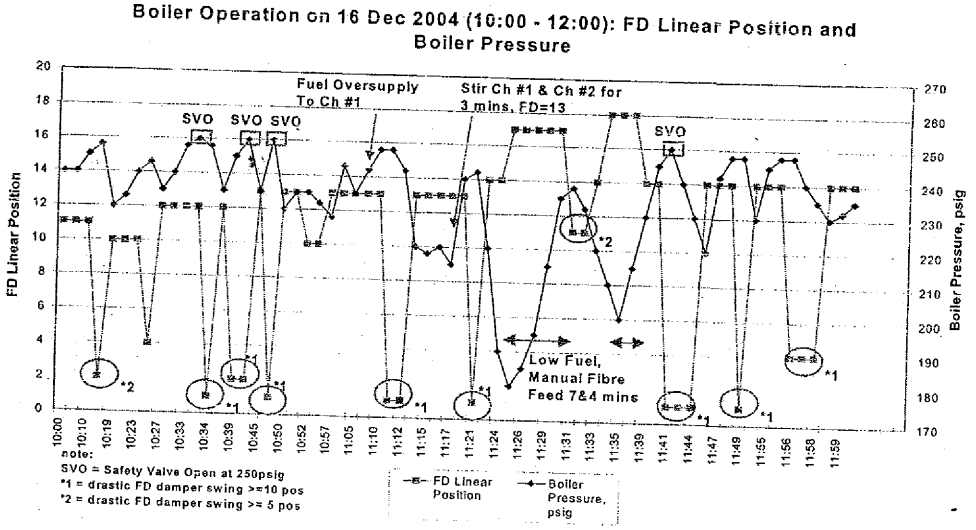


Figure 5. Boiler Pressure and FD Linear Position, std normal operation.

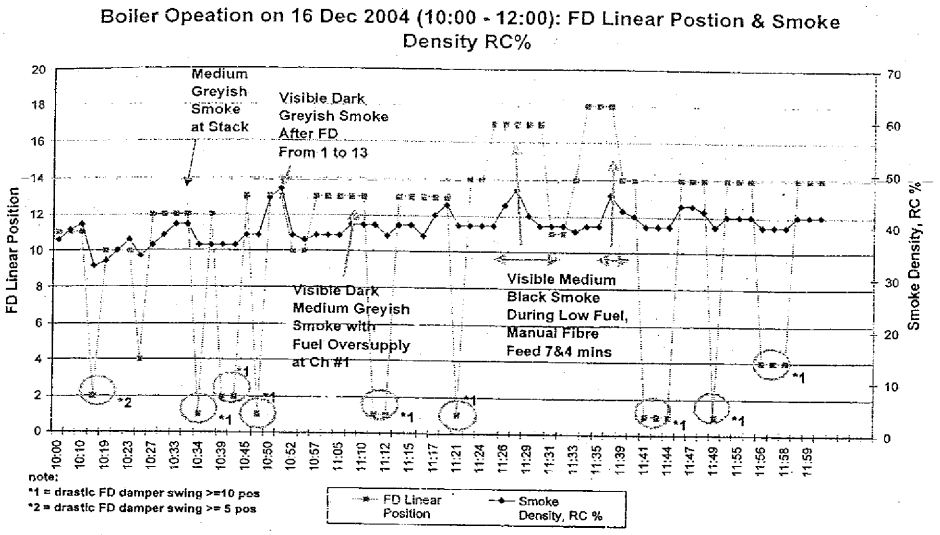


Figure 6. Boiler Smoke RC and FD Linear Position, std. normal operation.

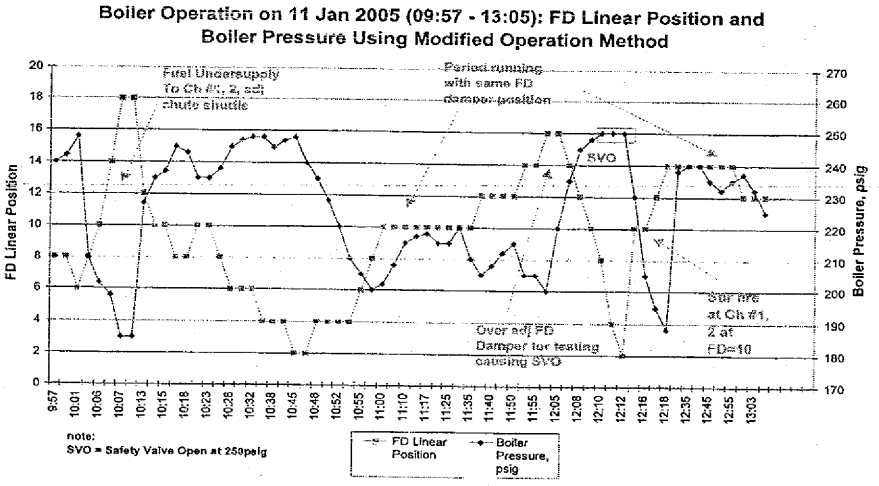


Figure 7. Boiler Pressure and FD Linear Position, modified operation.

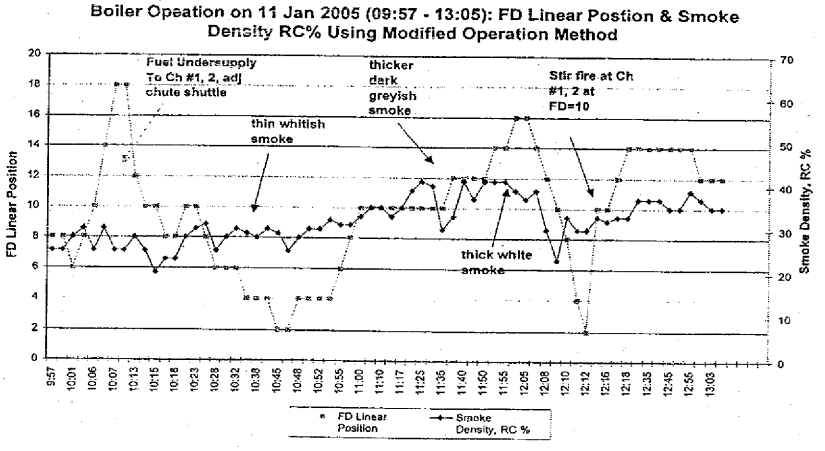


Figure 8. Boiler Smoke RC and FD Linear Position, modified operation.

The Boiler Stack Emission: The result of boiler stack emission monitor was base on 10 readings over a period of 40 minutes for each run. Run 1 used standar operating condition and Run 2 used modified operation method.

Under isokinetic condition of 102.7% and 109.2% as reported, overall results are tabulated on Table 1. It is noted that the modified condition seems to result in worst off particulate, carbon monoxide and sulphur dioxide.

Table 1. Summary of Stack Sampling Result

Parameters	*Run 1 Std normal condition, g/Nm^3*	*Run 2 modified condition, g/Nm^3*	*Remarks*
Particulate	0.3568g/ 1.049Nm^3 = 0.3402	0.3888g/ 1.011Nm^3 = 0.3846	summation over a period of 40 mins
Carbon Monoxide, CO	min = 0.399 ave = 0.589 max = 1.579	min = 1.120 ave = 2.756 max = 3.290	one data point every 4 mins for period of 40 mins
Nitrogen Dioxide, NO2	min = 0.0580 ave = 0.0902 max = 0.1066	min = 0.0353 ave = 0.0534 max = 0.0729	one data point every 4 mins for period of 40 mins
Sulfur Dioxide, SO2	min < 0.0026 ave = 0.0196 max = 0.1420	min = 0.0342 ave = 0.2621 max = 0.4629	one data point every 4 mins for period of 40 mins

DISCUSSION

Smoke Opacity: Although good control of FD damper has some effect on preventing a surge in smoke opacity and keeps the level consistently below 40% RC, it seems another key factor that has more pronounced effect on increasing the smoke opacity is the fuel itself. It has been noticed that whenever the fuel supply is not smooth and whenever additional wetter fibre or shell are added, tendency is that black smoke will be seen on stack and smoke density meter recorder also registered higher RC%.

Stirring the fire with FD damper wide open beyond 45 deg will also result in higher smoke opacity of up to 60% RC (see fig 4). The condition of de-duster also would play a role. It is learned that the existing cyclone de-duster is not in best condition, as its internal partition would have been corroded and some pass through without settling would have occurred.

Stack Emission: On the day conducting the stack emission sampling test, two events happened that could not add-value to result. Firstly, the LKS smoke density SMD-V3.1 was down, due to faulty light transmitter. Thus corresponding RC% during test cannot be recorded. Secondly, auto fuel supply for the Run1 using std normal condition was stopped for 1st half hour of initial part of test. And with the existing combustion coasting along just enough to maintain boiler pressure, stack emission was visibly good without load of black smoke. Subsequently, for 14 minutes period (10:14am to 10:28am), wetter fibre was manually topped up.

This proved to have negative effect on Run 2, whereby from 10:39am onwards, visible dark smoke was seen at the stack. Very high CO was also registered. On Run2, where modified condition was used, its improved effect was overshadowed perhaps by the new supply of fuel of fibre and shell, as throughout the Run2, some slight visible black smoke was observed. The other point observed was the sampling gas tube to the MRU was actually not connected all the time, to prevent saturating the equipment. It is only connected when reading is to be taken. It is not certain whether such configuration could affect result of Run 2 or not.

Operating at lower pressure of 220 psig has shown to place less constraint on the boiler. This prevents the safety valve from opening, thus prevent loss of steam energy, and eliminate the need to swing the FD damper drastically.

CONCLUSIONS

The results obtained for standard operation (SO) and modified operation (MO) method of the boiler has shown that The lower boiler operating pressure target at 220psig (MO) from 235psig (SO) minimized safety valve open problem at 250psig. Installation of the vertical linear scale (MO) at FD turn wheel improved the fire man's FD damper position control. The 5 degree per adjustment (MO) of FD damper also has shown to improve the boiler pressure control and the stack smoke opacity as compared to 30 degree adjustment (SO). Stirring the bed-fire at FD damper at 45 deg (MO) instead of more than 45 deg (SO) helps to minimize smoke emission. The stack monitoring of particulate and gaseous emission yielded data that did not support modified operation method being a better method. The probable reason that impacted the monitor could probably be the fuel supply. The standard operation method data was biased by a steady run without new fuel supply; whereas the modified operation method data was complicated by a period with wetter fibre from previous run and subsequently new auto fibre/shell supply for its on run. Therefore it can be concluded that though the dominant factor being the fuel supply itself, operating methods of the boiler and fire man/boiler man's training level can also impact the boiler's stack emission.

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EVALUATING AIR QUALITY USING TIME SERIES TECHNIQUE AND ELEMENTAL ANALYSIS OF SPM IN KERMAN, IRAN.

Saeid Rezaei Nejad, Mohd Sanusi S. Ahamad and Nor Azam Ramli
School of Civil Engineering, Engineering Campus,
University Sains Malaysia
14300, Nibong Tebal, Pulau Pinang
Email: rezaei_ikb@yahoo.com

ABSTRACT

The city of Kerman, as many other big cities in Iran, faces expanding urbanization, with economic growth, increase in air pollution, and loss of green or agricultural space. old cement plant with capacity of 3600 tons/day is located in the West edge of the city, because of improper location and adjacent to the residential area have significant effect in the air quality of the city The research adopted time series technique for analyzing of observed air pollutants in specific time in Kerman city. CO mean value for the specific period in 2004 in different parts of city is measured. In addition, the impacts of old cement plant in Kerman air quality was studied by analyzing the relevant data. The evaluation of carbon monoxide concentration among three runs of eight- hour periods indicates that the highest mean value is between 4 pm to 12 pm. The comparison seasonal mean values of CO in Kerman from the station demonstrate higher winter values compare to the summer. The monthly average of calcium in summer and winter 17.93 and 10.96 ug/m^3 respectively. This high relatively of Ca value is due to industrial pollution which mostly derived from the cement factory.

Keyword: Time Series, Calcium, Carbon monoxide

INTRODUCTION

Air pollution is one of the most important problems in all metropolitan cities in Iran (Energy Information Administration, 2002). Urban air pollution, in turn, is the source of a range of problems, including health risks with inhalation of gases and particles, accelerated corrosion and deterioration of materials, damage to historical monuments and buildings, and damage to vegetation in and near the city. A major factor behind the suffocating air pollution in urban Iranian area is the dramatic rise in the country's energy consumption. From 1980-1998, Iran's total energy consumption ramped up from 1.6 quadrillion Btu (quads) in 1980 to 4.7 quads in 2000 nearly a three- fold increase. Moreover, Iran's energy-related carbon emissions have been on a steady climb for two decades. Since 1980, carbon emissions in Iran have risen by 240%, from 33.1 million metric tons emitted in 1980 to 80.8 million metric tons emitted in 2000(Energy Information Administration, 2002).

Although Iran consumes very little carbon-intensive coal, the carbon emission is relatively high. This is due to the predominance of cars lacking catalytic converters in Iran accounts for significant levels of carbon monoxide in urban areas. In addition, since 40 percent of the cars in Iran are at least two decades age

enhance much carbon emission in cities (Ministry of Industries and Mines of Iran, 2000).

Table 1. Age Distribution of vehicles in Iran, 2000 (Source: Saeid et al., 2005)

Age (years)	Market share(percentage)
0-5	32.9
6-10	10.9
11-15	3.2
16-20	10.6
>20	42.4

The country's carbon emissions to be expected will increase until the roots of the problem are addressed. Shortage of public transport, high growth population, and the very high price of new and cleaner cars are the reasons for remaining large numbers of cars lacking pollution-abatement technology on the road, in spite of health problems they cause.

According to the United Nations Environmental Programme (UNEP), suspended particulate matter (SPM) is the most significant source of air pollution affecting the world's largest cities (WHO/UNEP, 1992). In the United States, ambient monitoring was revised in 1987 and 1997 to measure levels of PM_{10} (particles < 10 μm in diameter) and $PM_{2.5}$ (particles < 2.5 μm in diameter) (USEPA, 1987, 1996).The reason for such revision is mainly due to the fact that smaller particulates have higher impact on human health. While real time monitoring of SPM could provide valuable data regarding the existing pollution levels, it does not describe the nature of pollution. To examine the sources and nature of the SPM pollution, elemental analysis of SPM is required. In such analysis, specific elements from different pollution sources are analyzed. As an instance, such studies have been carried out in the Czech Republic to estimate the apportionment of the individual emission source types to the level of pollution in a particular area (Kucear et al., 1993) and again in Buenos Aires providing information about the elemental profile of the atmosphere of the city (Pla et al., 1993). A similar study was conducted in Tehran to evaluate the contribution of different emission sources to Tehran SPM pollution (Sohrabpour et al., 1999)

The city of Kerman, as many other big cities in Iran, faces expanding urbanization, with economic growth, increase in air pollution, and loss of green space. The city of Kerman is located in a large and flat plain about 1076 kilometers from Tehran, the national capital of Iran. It has been a historical town and it is the provincial capital now. The city has about 550,000 inhabitants is placed at the eastern south in Iran, with longitude between 49.736°(DD) and 51.223°(DD), and latitude between 33.453°(DD) and 33.457°(DD)with an urban extension of 80 square km and 1710 meters at the sea level. The city is located on the flanks of the Loot desert. The region is mostly classified within hot and dry climate in the summer and moderately dry in the winter. The annual rainfall reaches 146mm and the average annual relative humidity is 32%. January is the coolest month with a daily average

temperature of 6.2°C while in July the daily average temperature reaches 28.1°C for the warmest month .The maximum hourly average temperature in the city is 40.3°c while the minimum hourly temperature reaches -10.3°C .The annual mean wind speed is 3.1ms^{-1}, whilst the predominant wind directions are: NNW 19.77%, ENE 18%, NNE12.8%, N 11.63%, NE 11%.for the year 2004 (Saeid et al., 2005).

Statistical Analysis of Air Quality Dataset: If a number of air quality observations have been made at a given place, the information is usually concentrated in tables or graphs. Often, a further step toward concentration is undertaken by condensing groups of figures into averaged coupled with their standard deviations: these are called descriptive statistical parameters, and the tabulation, averaging, etc., process is called descriptive statistics (Benarie, 1980).

Time Series: By a time series we mean a set of observations $\varkappa(t_1)$, $\varkappa(t_2),\ldots,\varkappa(t_n)$,where $t_1, t_2,\ldots,t_n$ denote time and $\varkappa(t)$ the corresponding observations .The time series technique was applied by Saxene and Tsao(1971), by Barlow and Singapurwalla (1972) to carbon monoxide data in Livermore, California, and by Tiao et al. (1973 a) and McCollister and Wilson(1975) for forecasting pollutants concentration in the Los Angeles basin.

The Annual Cycle: Many observation of air pollution are recorded and published as monthly averages, showing, at superficial inspection, regular variations. Although different contaminants do not vary exactly in the same way during the year, the typical maxima are more or less in the same seasons. It seems almost that each town, according to its climatological situation, its activity linked to pollutant emissions and its population density and number, belongs to a given type of annual cycle (Benarie, 1980).

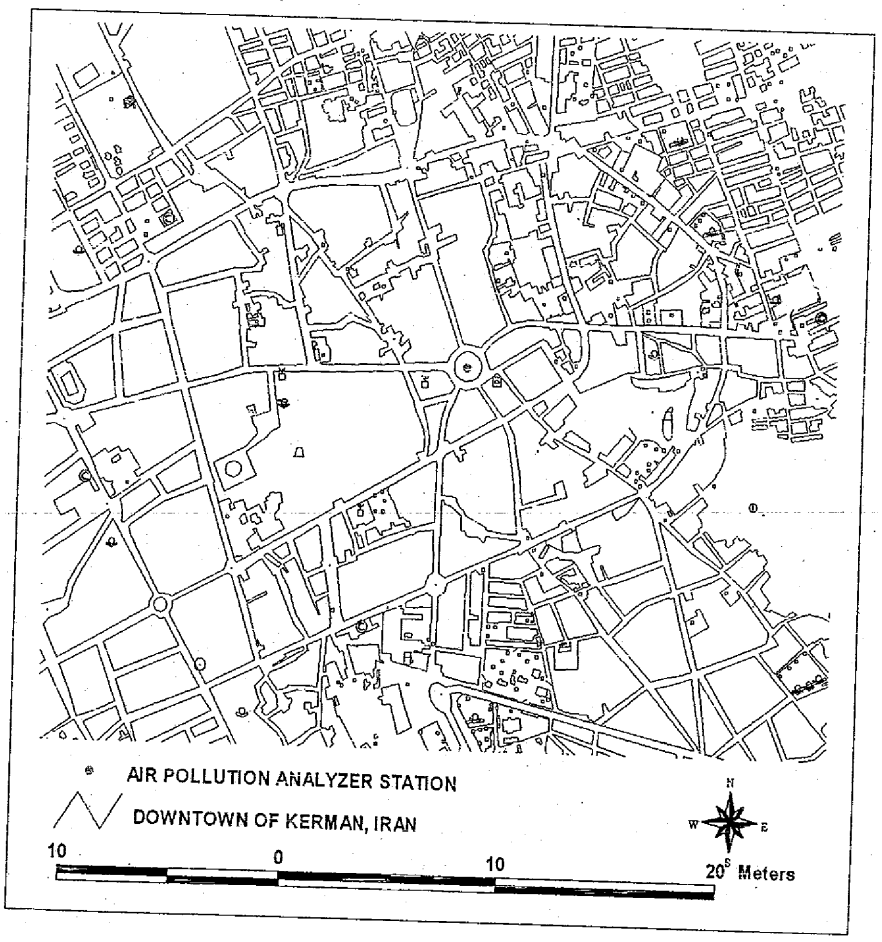
Weekly Cycles: The annual and daily cycles combine the effects of anthropogenic and meteorological factors while, the weekly is exclusively anthropogenic. The week cycle of pollution has been studied in many cites. The oxidants precursors have been linked to the change in the weekday and/or weekend automobile traffic (Benarie, 1980).

Diurnal Cycles: The diurnal and annual variation of pollutant concentrations tend to interfere with each other. The diurnal variation of sulphur dioxide and suspended matter, with a morning peak and a smaller secondary peak in the evening, belongs to one of the earliest phenomenological generations in air pollution. This pattern predominates during the cool periods of the year and in cites where space heating is the predominate source of these two pollutants (Benarie, 1980).

METHODOLOGY

The data is collected from the air pollution analyzer station (Model HORIBA 360) has been set in the Shohada square in the downtown of Kerman (Map 1). Analysis of diurnal, weekly and seasonal of CO, NO, collected by air pollutant analyzer station is carried out by means of descriptive statistics. The SPSS software version 12.0.1 is used for this purpose.

In addition, the impacts of old cement plant in Kerman air quality was studied by analyzing the relevant data. To examine the source of SPM pollution in the city, elemental analysis of SPM is carried out. Instrumental neutron activation analysis (INAA) was the major method for suspended particulate matter analysis, providing high accuracy. The sampling was done in residential area in the neighborhood of the Kerman cement factory. The air sampler used Whatman-41 filters with 12.5 cm diameter. Altogether, 60 samples were collected over a 6- month period. The air sampler's pump flow rate was set at 5 m^3/h and through each filter nominally 200 m^3 of air was drawn.



Map 1 Air pollution monitoring station in downtown of Kerman (Source: Saeid et al., 2005)

RESULTS AND DISCUSSION

Diurnal Cycle Air Pollutants Analysis: Table 2 Carbon monoxide concentration among three runs of eight- hour periods indicates that the highest mean value is between 4 pm to 12 pm. Since, the basic source of CO is automobile emission; this evening peak takes place because of the traffic jam caused by the rush hour period, especially in downtown area.

Table 2 Carbon monoxide concentration (ppm) 8 hours period, Kerman 2004- 05(Source: Saeid et al., 2005)

Period	Sample number	Minimum	Maximum	Mean	Std. deviation	Variance
00-08	223	00.0	5.01	1.67	0.84	0.71
08-16	223	0.18	5.39	2.37	0.87	0.76
16-00	223	00.0	9.77	3.17	1.7	2.9

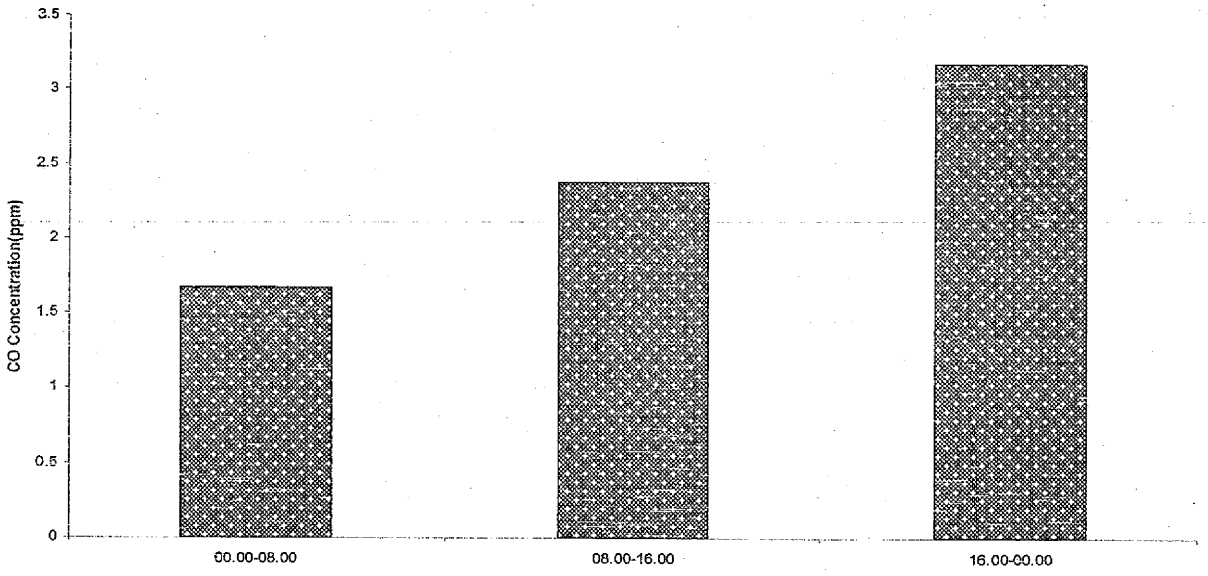


Figure 1. Carbon monoxide concentration (ppm) 8 hours period, Kerman 2004 -05 (Source: Saeid et al., 2005)

Figure 2 shows the diurnal cycle and fluctuation for carbon monoxide and concentration at the specific period in the city. High relatively values were observed in the winter's months in comparison with summer's months. This phenomenon is due to using the fossil fuel for heating space during this period of year.

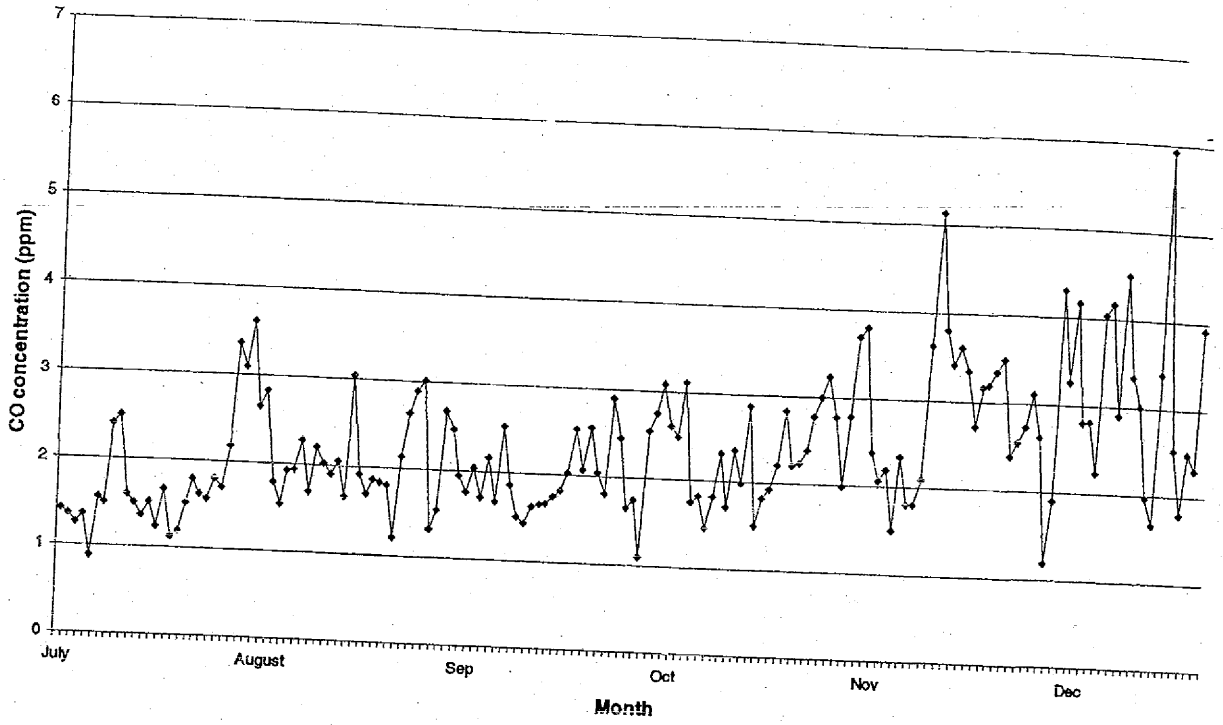


Figure 2 Diurnal Carbon monoxide concentration (ppm) 2004 Kerman

Seasonal Cycle: The comparison seasonal mean values of CO in Kerman from the station demonstrate higher winter values compare to the summer (Table 3). Such tendencies are largely attributed to the use of large amounts of fuel for space heating during the winter months.

Table 3 Seasonal carbon monoxide concentration (ppm), Kerman 2004 -05

Season	Sample Number	Minimum	Maximum	Mean	Std. Deviation	Variance
Summer	74	0.89	3.62	1.93	0.55	0.31
Winter	143	1.10	5.93	2.74	0.84	0.71

Comparison of Observed Data with the National Ambient Air Quality Standard and Pollutant Standards Index (PSI): The pollutant standard index (PSI) equates the scale value 100 to the shortest-term concentration. Figure 3 illustrates the air quality in Kerman for the specific period of time. The Figure shows 84 percent of days observed in this period have a good air quality, 15 percent moderate, whilst just 1 percent of days have unhealthy air quality in the city.

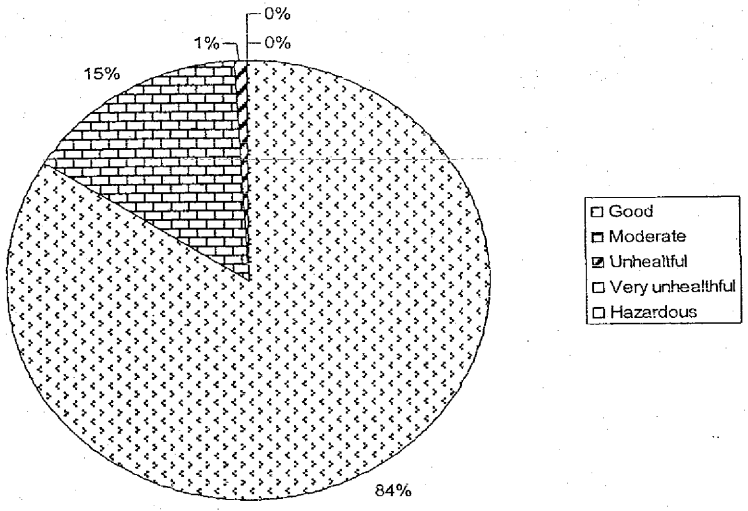


Figure 3. Carbon monoxide compares with the pollutant standards Index (PSI)2004(Source: Saeid et al., 2005)

Industrial Sources Relevant to the City Air Quality: The main industrial sources have been contributed in the air pollution in the city are located (a) old cement plant (Kerman cement Co.) with capacity of 3600 tons/day (Kerman cement, 2005) in the West edge of the city, because of improper location and adjacent to the residential area have significant effect in the air quality of the city. In addition, asbestos-cement factory (Kermanite Co.) next to the Kerman cement plant which produces asbestos-cement, corrugated and plane sheets, sewers and high pressure water conduits enhances the problems of air quality in the city. (b) a rubber plant in the South of the city due to some distance and location in downwind has less significant impact on the air resource, (c) The agro and food production e.g. dairy plant located in the Eastern south site, but with less impact on the air quality in the city(Saeid et al., 2005)

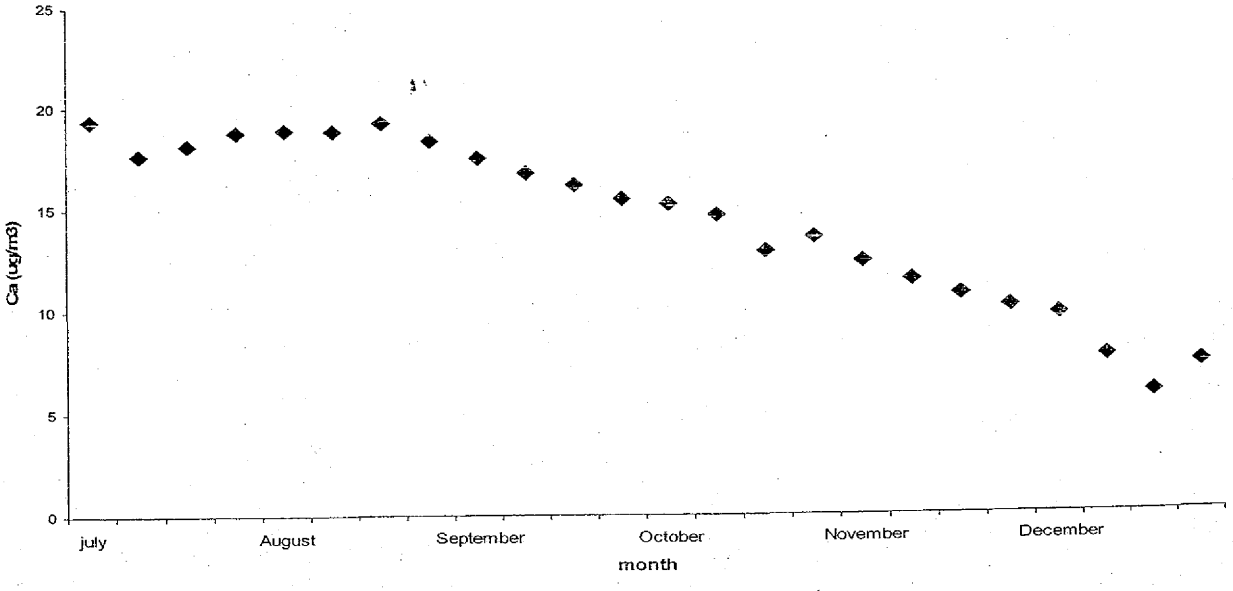


Figure 4. Calcium concentration in the district in close proximity to the old cement factory 2004

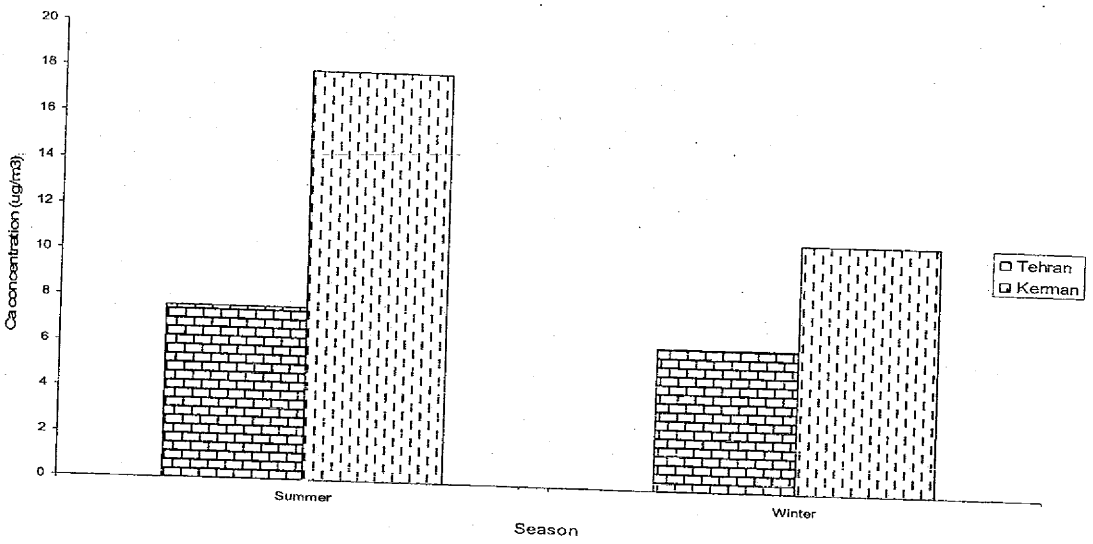
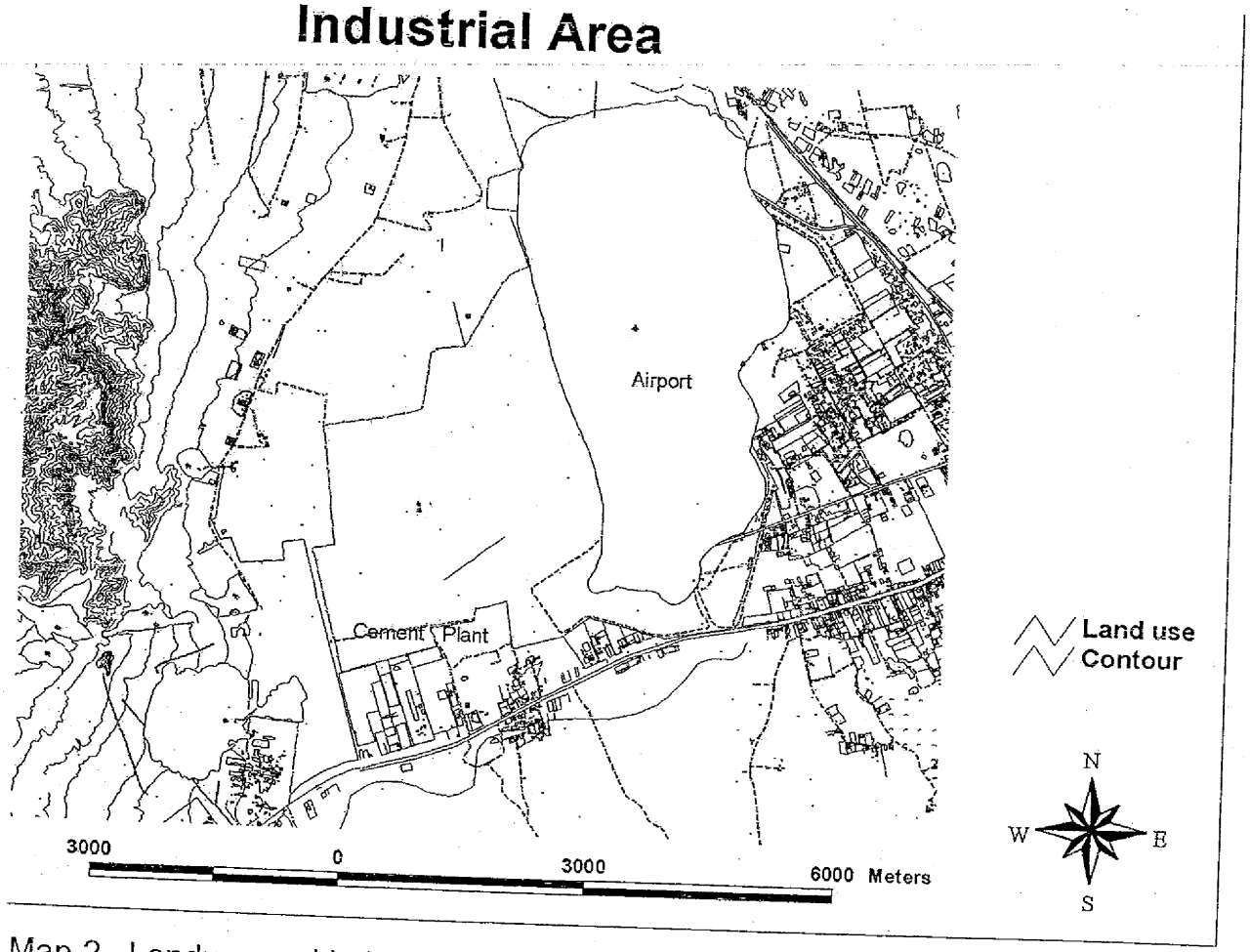


Figure 5. Compare calcium concentration (μg/m^3) between Tehran and Kerman in summer and winter respectively



Map 2. Landuse and industrial area and cement factory (Source: Saeid et al., 2005)

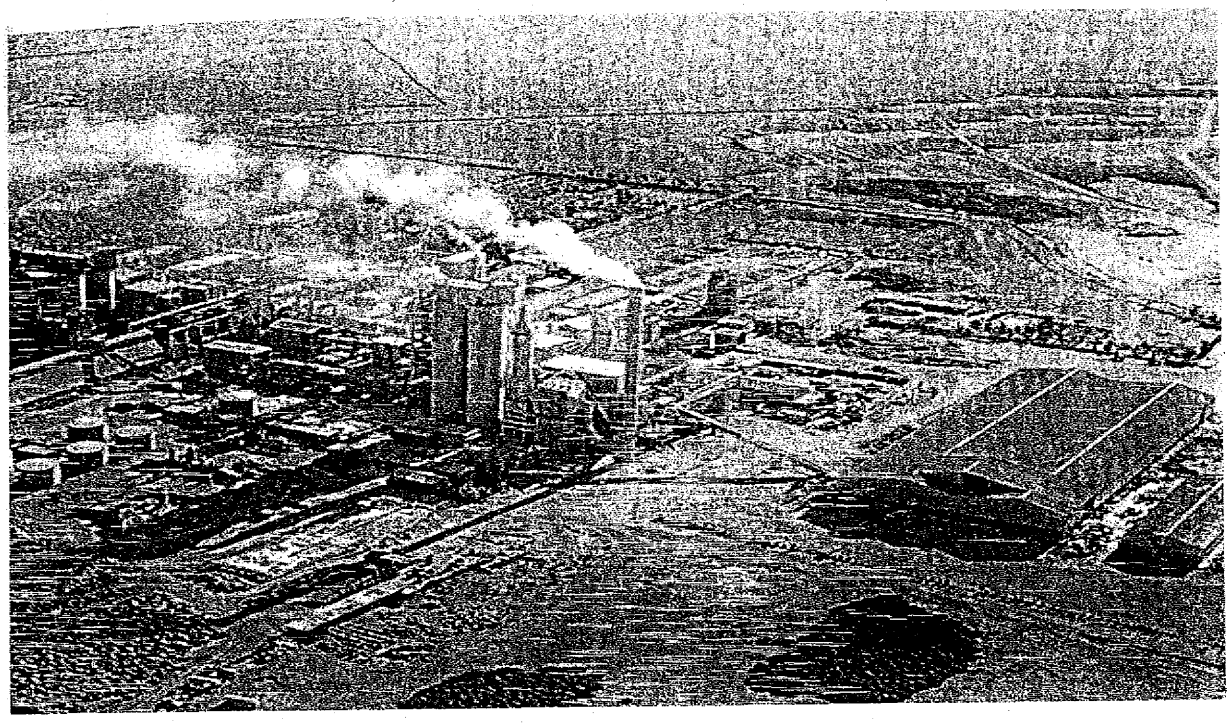


Plate 1 Kerman cement factory

Figure 4 shows the variation of calcium concentration in different months. This variation matches the rainfall fluctuation of Kerman; the precipitation usually starts in November and continues till April. Figure 5 shows that the monthly average of calcium in summer and winter 17.93 and 10.96 ug/m3 respectively compare to Tehran 7.6 and 6.3 respectively (Sohrabpour, et al. 1999). Consequently, Ca has a higher concentration than Tehran (approximately two times).

The main probable reasons are as follows:

I. Climatologic specification in Kerman, in particular dryness of the weather during summer.
II. Present of old cement factory located in southern west of the city, as it has been shown in the Map 2 nearby to the residential area. Although Ca has both natural and industrial derivation, higher ratio of pollution is due to industrial pollution which derived from the cement factory.

CONCLUSION

In the current research, Instrumental neutron activation analysis (INAA) was applied for elemental analysis. The peak of carbon monoxide in eight –hour period monitored in the air pollution station located in downtown was observed in the evening with value of 3.2 (ppm). Carbon monoxide concentration mean values are 1.93 and 2.74 (ppm) in summer and winter respectively. Furthermore, elemental analysis of SPM has shown high considerably concentration of Ca especially in the summer. The mean values are 17.93 and 10.96 ug/m3 in summer and winter respectively. Therefore, the old cement factory has immense impact in the air quality of city due to inappropriate location.

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AIR QUALITY PREDICTION AT NEWLY DEVELOPED CITY WITH MANY EXTERNAL SOURCES

Hamed Mehrabi, Nor Azam Ramli, Ahmed Shukri Yahaya, Ali Aakbar Zinatizadeh

School of Civil Engineering, Engineering Campus,
Universiti Sains Malaysia, 14300 Nibong Tebal, Penang, Malaysia
E-mail: hamed12@gmail.com

ABSTRACT

Iran is a fast growing economy. Kermanshah is a city located in the west of Iran which is an industrialized but polluted by industries such as cement factory, thermal power plant and many asphalt factories located outside the city. The population around the city is about one million. Emissions of the two polluted industries were investigated seasonally in order to estimate dispersion of CO and SO_2 caused by those industries. The Gaussian model was then employed for predicting the ground level concentration of CO and SO_2 at various distances downwind of emission sources. Plume rise was computed by Holland and Briggs methods in stability classes A and D at summer and winter seasons. Based on pollutant dispersion model, thermal power plant has been considered as major pollutant source of SO_2. Cement factory had no significant effect on air quality of the city. Pollutant concentration were estimated from various distances during the winter and summer months. Nonparametric statistical procedure was carried out to determine whether there is significant difference between summer and winter seasons. The results show that; (Mehrabi *et al.*, 2005a) For both CO and SO_2, there is significant difference between summer and winter seasons. (Mehrabi, *et al.*, 2005b) For CO, stability D gives a significant difference when both methods are compared. (3) For SO_2, stability A gives a significant difference when both methods are compared.

Keywords: Gaussian Dispersion Model, Ground Level Concentration, CO, SO_2.

INTRODUCTION

Today environmental problems in urban areas are showing an increasing trend. Ambient air pollution is an emerging environmental issue in major cities of Asia and has attracted attention from variety of corners with a proven direct impact on health and ecosystem of earth (Qadir, 2002). Air pollution, water pollution, noise pollution and solid waste problem are the problems of most common type which are generally considered an indicative sing of urbanization. Kermanshah, a densely inhabited and industrialized area, located on the west of Iran, is regularly affected by high SO_2 and CO levels, especially during summer months. In this case, external air pollution sources have been searched to find out whether affect on SO_2 and CO levels of the air quality of Kermanshah.

The perfect air pollutant concentration model would result from any specified set of pollutant emissions, for any time period, with total confidence in our prediction. Gaussian plume idea is a material balance model. In it, one considers a point source

such as a factory smokestack and attempts to compute the downwind concentration resulting from this point source. The origin of the coordinate system is placed at the base of the smokestack, with the x axis aligned in the downwind direction. The contaminated gas stream is shown rising from the smokestack and then leveling off to travel in the x direction and spreading in the y and z directions as it travels (De Nevers, 1995).

Cement production and thermal power plant are two of the oldest industries in Kermanshah which have developed along with the urban growth. They are located on the right side of the city so that the city is faced with air pollution problem. According to the results obtained from the air quality monitoring at the different areas of the city, it showed high pollution concentration in terms of CO and SO_2. However, measurement of the contribution of a particular plant to the air quality is very costly and time consuming. So, a simple and helpful air quality model was used properly with reliable input data. Gaussian dispersion model has been employed to evaluate the air quality contribution of a plant.

This paper is based on estimation of downwind concentration of major air pollutants from a point source. The objective of this study is to calculate the ground level SO_2 and CO concentrations at the different distances away from the cement plant and thermal power plant stack.

GENERAL INFORMATION ABOUT KERMANSHAH

Kermanshah is located on the west of Iran. The city is surrounded by many industrial factories from north, west and east. The altitude on north of the city is 1320 m and towards south of the city increases to 1360 m. The altitude of the city is about 1322 m above the sea level. As it is situated between two cold and warm regions enjoys a moderate climate. The average rainfall is about 450.8 mm, annually. The maximum and minimum temperature recorded over 50 years is 22.5°C and 5.8°C, respectively. The maximum wind speed over last 50 years is 60 (nott) on 30. Sep. 1975. The average wind speed is about 4 m/sec. The most dominant wind directions are WNW and ESE. The maximum and minimum average amounts of relative humidity were 74 % and 23 % January and August, respectively.

MATERIALS AND METHODS

In this modeling two plants are considered. The names of the plants and all the properties are given in Table 1. Cement plant and thermal power plant are located at 16 km and 24 km away on the right side of the city, respectively. The emissions were measured by the Department of Environment of Kermanshah. CO contribution of the cement plant and SO_2 contribution of the power plant have been investigated. Sampling operations from the stacks were carried out at two seasons (winter and summer), three times in each season during working hours. The Gaussian dispersion model was employed to predict concentration of the pollutants at various distances downwind of emission sources and the impact of main existing sources on urban areas. The stability classes of the atmosphere in Kermanshah are classified as A, B, C and D classes. The estimations of σy and σz by Holland and Briggs for rural situation, for distance between source and receptor have been calculated. The maximum and minimum pasquill stabilities, A and D have been determined for

calculation of plume rise. Plume rise and effective height of the stack we computed by, Holland and Briggs methods. Results are given in Table 2 and 3.

Nonparametric statistics was used because the data is not normal. T Wilcoxon signed rank test was used to do the analysis because the data w collected at the same site but at different seasons.

RESULTS AND DISCUSSION

The seasonal average concentrations of CO and SO_2 emitted from cemer and power plant stacks at summer and winter are given in Table 1 which is highe than Iran Emission Standards from the factories. Plume rise for both plants ha been calculated by Holland and Briggs, and results are given in Table 2 and 3 respectively.

Table 1. Qualitative and Quantitative Characteristics from Outside Stationary Sources

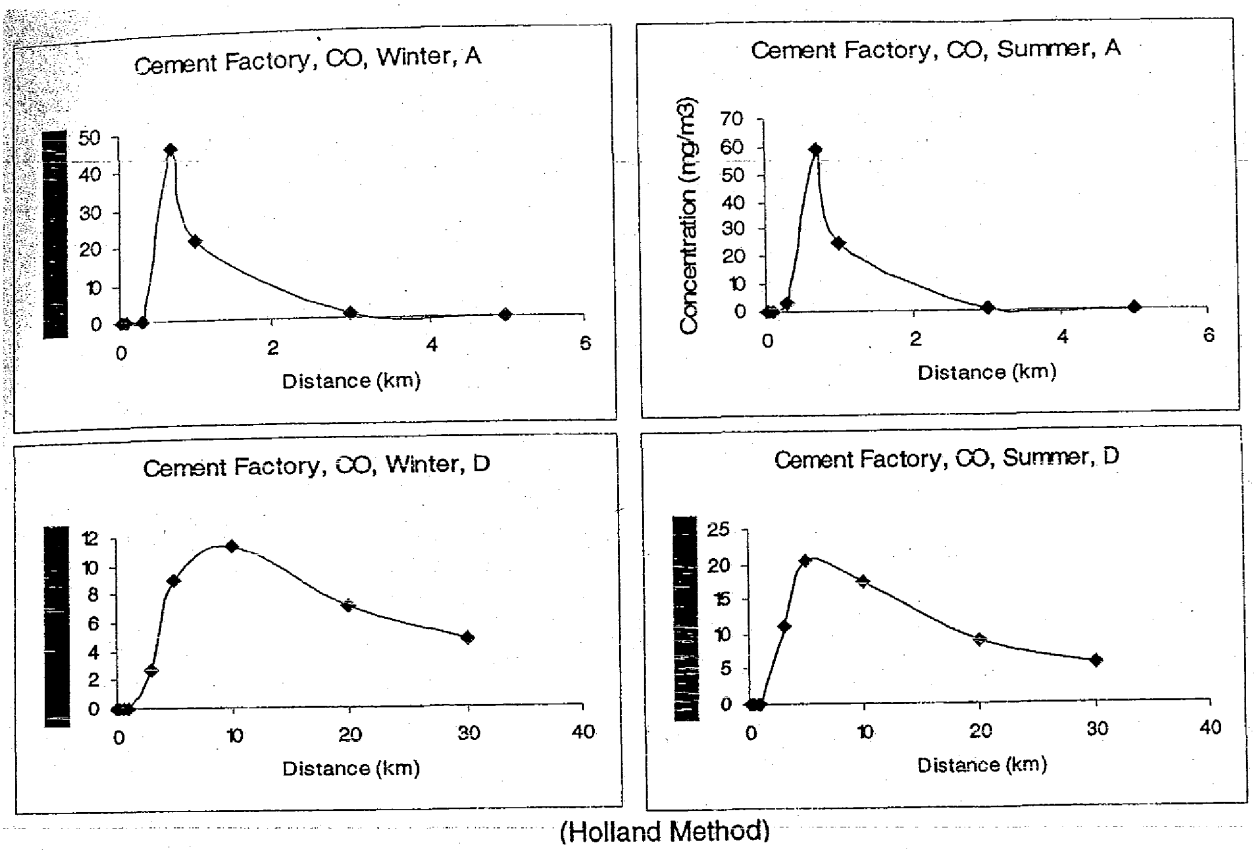
Name Of Factory	Q(m^3/h)	Exit Gas Temp. (Ts^0C)	Exit Gas Velocity Vs(m/s)	Stack Characteristics		Exit Gases from Stacks			
						Jan – Feb (Winter)		Jul – Aug (Summer)	
				Height (m)	Diameter (m)	CO ppm	SO_2 ppm	CO ppm	SO_2 ppm
Cement Plant	284860.8	96.5	11.2	90	3	380	29	430	41
Thermal Power Plant	1235051	145	24.99	164	4.18	47	1190	63	1200

Table 2. Calculated Plume Rise by Holland Method

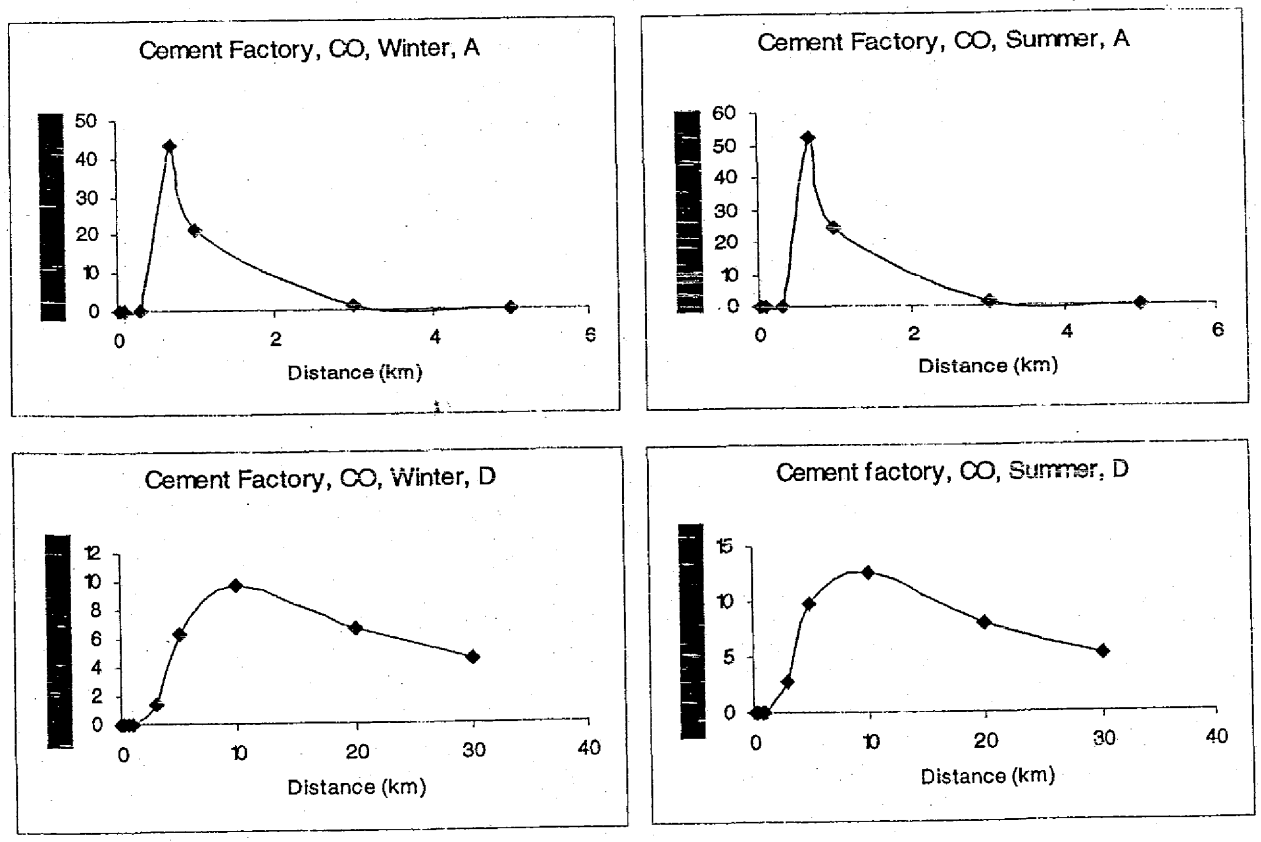
Name Of Factory	Stack Characteristics		Winter		Summer	
	Height (m)	Diameter (m)	H	Δh	H	Δh
Cement Plant	90	3	189.3	99.3	157.2	67.2
Power Plant	164	4.18	578.6	414.6	439.9	275.9

Table 3. Calculated Plume Rise by Briggs Method

Name Of Factory	Stack Characteristics		Winter		Summer	
	Height (m)	Diameter (m)	H	Δh	H	Δh
Cement Plant	90	3	203.3	113.3	190.3	100.3
Power Plant	164	4.18	492.7	328.7	468.2	304.2

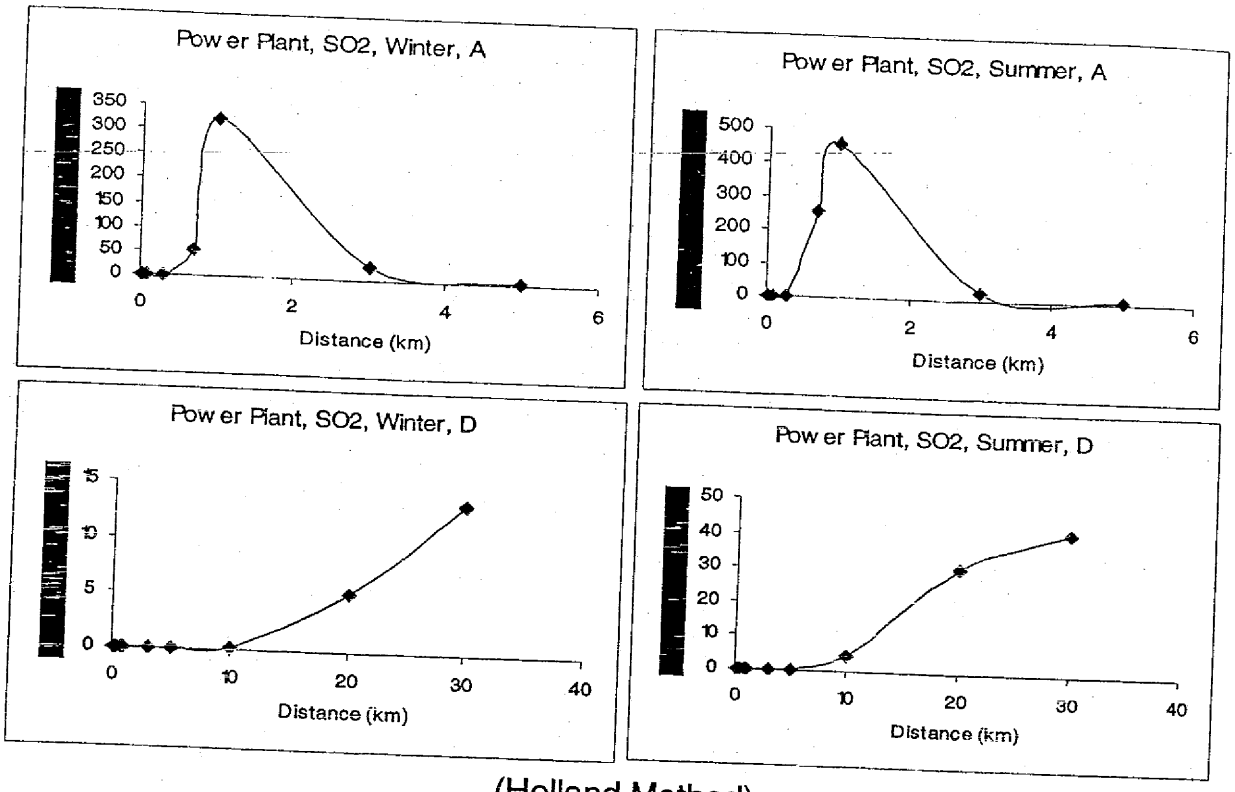


(Holland Method)

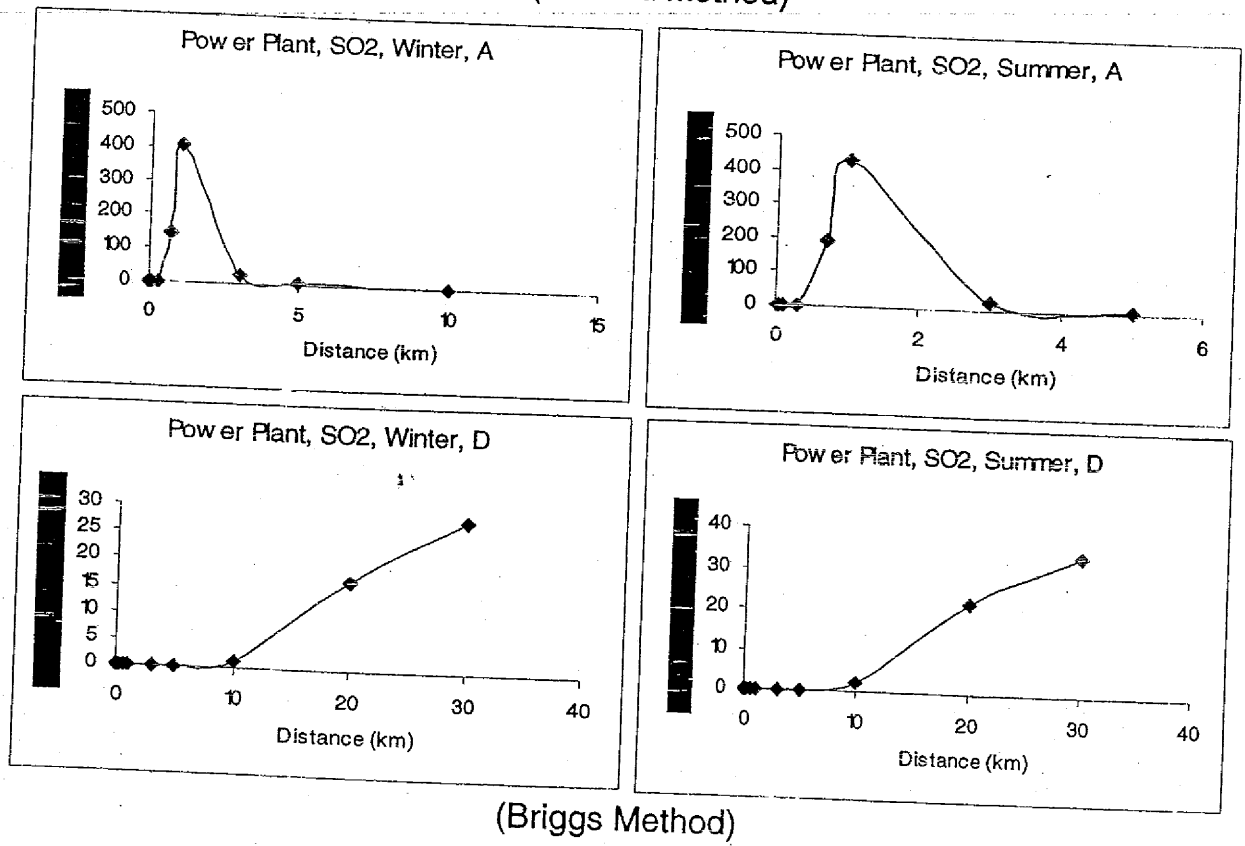


(Briggs Method)

Figure 1. Gaussian Dispersion Model for CO (µg/m^3) Emitted from Cement Plant



(Holland Method)



(Briggs Method)

Figure 2. Gaussian Dispersion Model for SO_2 ($\mu g/m^3$) Emitted from Thermal Power Plant

According to the results obtained from Gaussian dispersion equation, the maximum ground level concentration of CO is 59.14 µg/m^3 at the 0.7 km away of cement plant stack, class A and summer, (Figure 1a & b). High CO values have been estimated at the distance of 0.3 km to 5 km at stability A (Figure 3). There are increasing values of CO over 3 km away of the plant stack, at two seasons and in stability D (Figure 1). Figure 4 show CO concentrations at the different distances downwind of the cement factory stack.

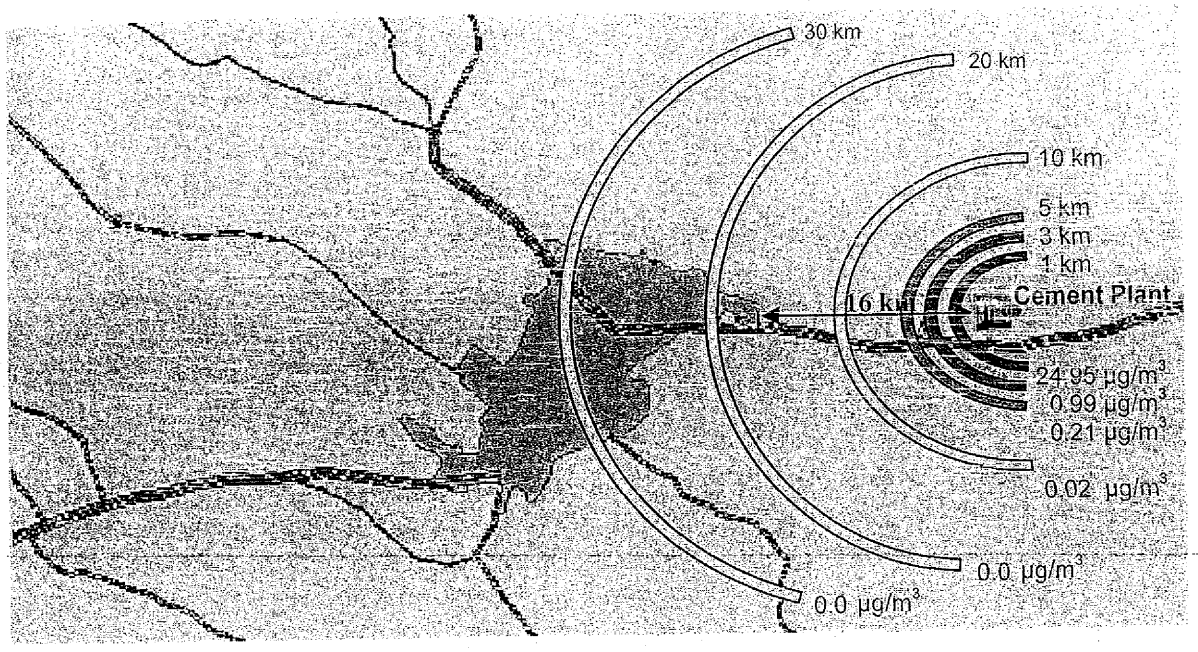


Figure 3. Ground Level Concentration of CO at Stability A, Summer & Holland Method

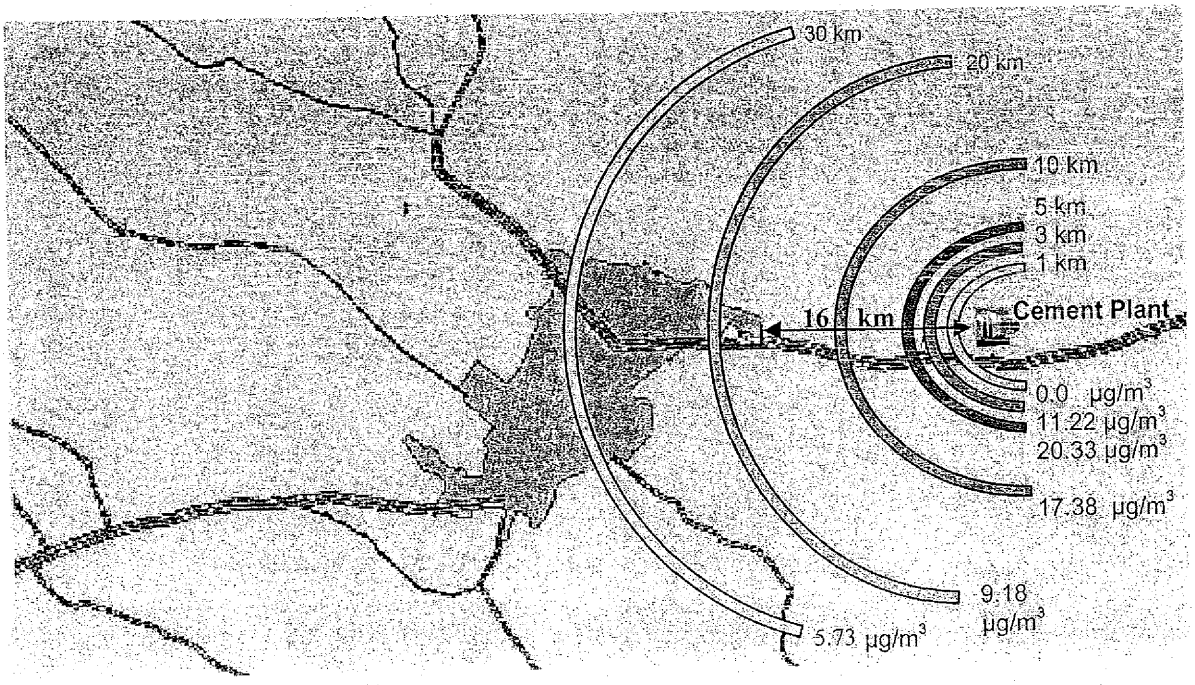


Figure 4. Ground Level Concentration of CO at Stability D, Summer & Holland Method

The maximum estimated SO_2 value is 458.25 at the distance of 1 km at the stabilit A in the summer by Holland. High SO_2 values have been estimated at the distanc of 0.3 km to 5 km at stability class A (Figure 2 and 5). Figure 6 show that groun level concentration of SO_2 downwind of plant stack are increasing over distance o 10 km.

Using the Wilcoxon signed ranks test we obtained $Z = -2.023$ [P value = 0.043]. Thus the test is significant at $\alpha = 0.05$. Therefore the mean concentration fo SO_2 in summer is different from the concentration in winter. From the results it can be concluded that SO_2 in summer is higher than SO_2 in winter.

For both Holland and Briggs methods using stability classes A and D there are significant differences between two seasons.

When we compare between summer and winter seasons, both Holland and Briggs methods, using stability classes A and D produces significant results. This shows that the concentration of CO is different during winter as compared to summer season.

Comparison between Holland and Briggs methods shows that there is no significant difference ($P\text{-Value}_{CO,SO2}$ = 0.109) when stability class A was used. However, when stability class D is used, there is slightly significant difference between two methods.

Comparison between summer and winter seasons show that when stability class A was used there is significant difference. However, when stability class D was used both Holland and Briggs methods does not show significant difference for SO_2 shows significant for CO.

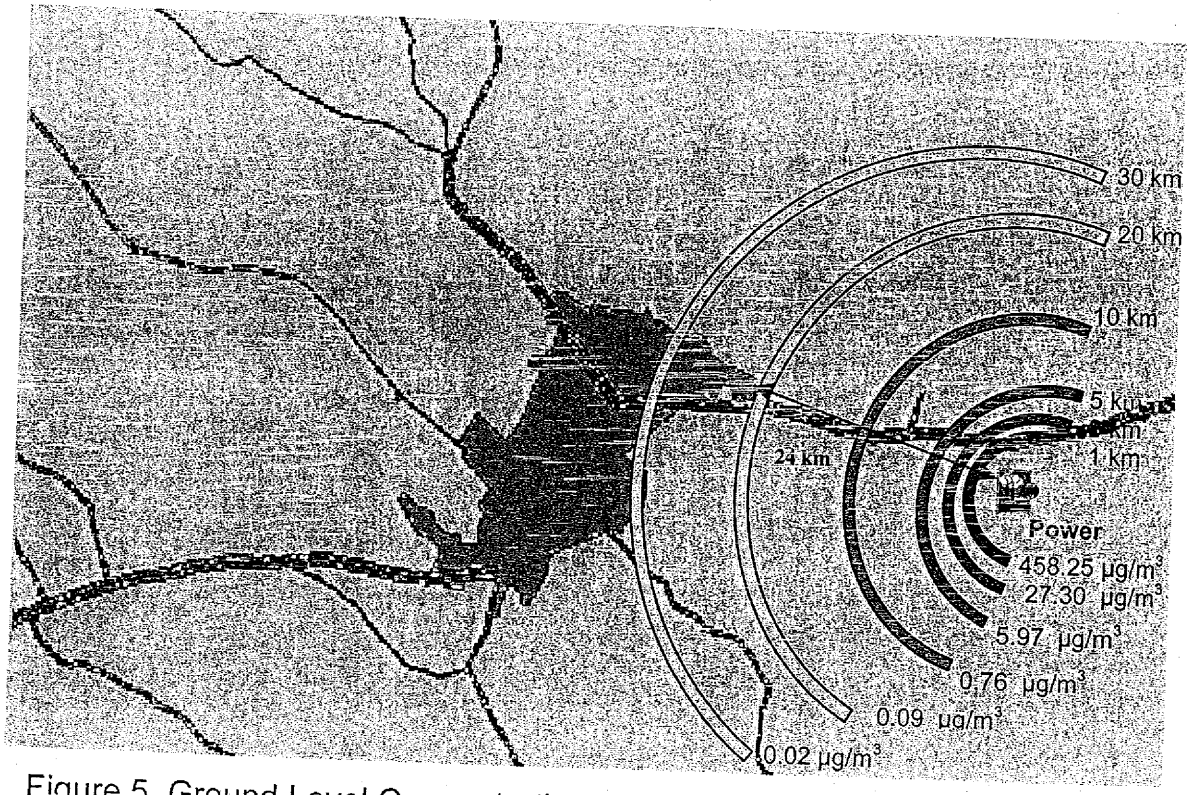


Figure 5. Ground Level Concentration of SO_2 at Stability A, Summer & Holland Method

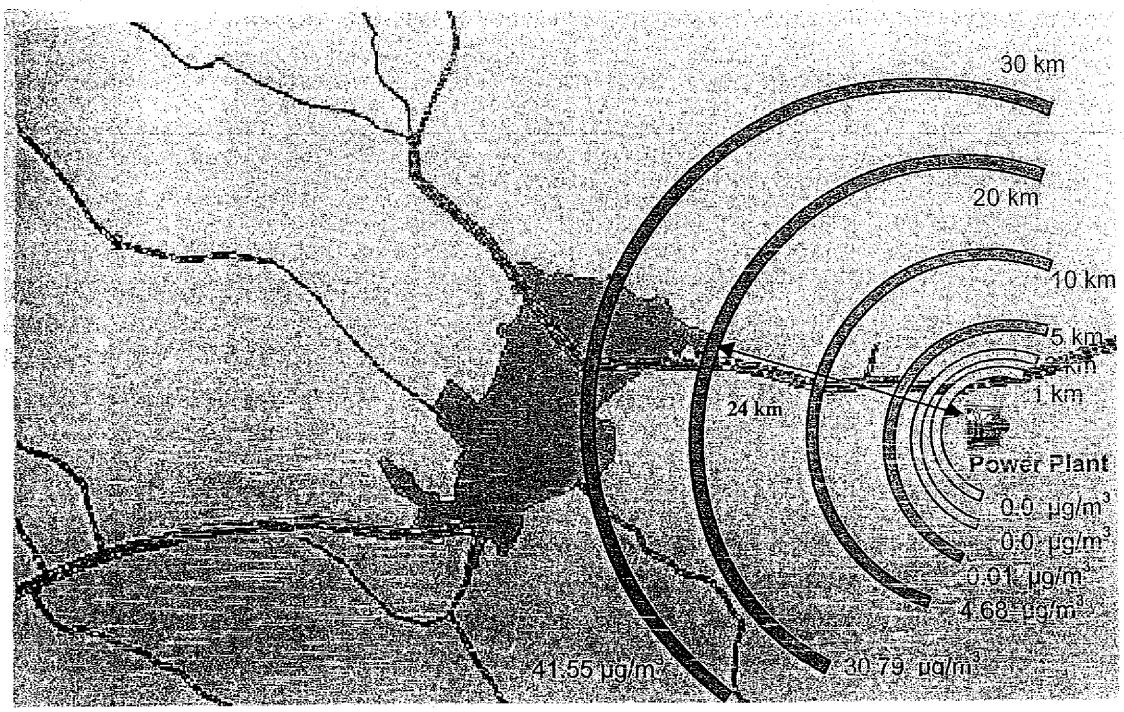


Figure 6. Ground Level Concentration of SO_2 at Stability D, Summer & Holland Method

Table 4. Analyzing Data of CO, Compare Summer to Winter Seasons

Stability \ Season	Summer	Winter	Z	P-Value	Result
A					
Holland	8.8720	6.9000	-2.208	0.027	Significant
Briggs	7.7860	6.5830	-2.023	0.043	Significant
D					
Holland	7.9492	3.8400	-2.023	0.043	Significant
Briggs	4.2833	3.1589	-2.023	0.043	Significant

Table 5. Analyzing Data of CO, Compare Holland to Briggs Methods

Season \ Method	Holland	Briggs	Z	P-Value	Result
Summer					
A	8.8720	7.7860	-1.604	0.109	Not Significant
D	7.0933	4.2833	-2.023	0.043	Significant
Winter					
A	6.9000	6.5830	-1.461	0.144	Not Significant
D	3.8400	3.1589	-2.023	0.043	Significant

Table 6. Analyzing Data of SO_2, Compare Summer to Winter Seasons

Stability \ Season	Summer	Winter	Z	P-Value	Result
A					
Holland	74.6920	40.9540	-2.023	0.043	Significant
Briggs	65.6420	58.3670	-2.366	0.018	Significant
D					
Holland	8.5589	2.0822	-1.826	0.068	Not Significani
Briggs	6.5033	5.0644	-1.604	0.109	Not Significant

Table 7. Analyzing Data of SO_2, Compare Holland to Briggs Methods

Season \ Method	Holland	Briggs	Z	P-Value	Result
Summer					
A	74.6920	65.6420	-1.604	0.109	Not Significant
D	8.5589	6.5033	-1.826	0.068	Not Significant
Winter					
A	40.9540	58.3670	-0.944	0.345	Not Significant
D	2.0822	5.0644	-1.604	0.109	Not Significant

When the Holland and Briggs methods were compared there is no significant difference for both types of stability classes. For SO_2 both methods can be used to calculate plume rise.

CONCLUSIONS

According to the results obtained by Gaussian dispersion model in stability A, using Holland and Briggs, and at two seasons, CO and SO_2 emitted from cement and power plants stack had no significant effect on air quality of the city due to the 16 km and 24 km distance of plants away of the city, respectively. Based on this approximation, in the stability D, cement and power plants can be the probable air pollution sources in terms of CO and SO_2 .

The most important parameter which can affect the air quality of Kermanshah is the distance of these factories from the city. However, ground level concentrations have been calculated, they would depend on wind speed and on the degree of atmospheric turbulence, which a function of wind speed and degree is.

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STEADY STATE PROBABILITIES FOR CARBON MONOXIDE CONCENTRATION IN KUALA LUMPUR

AHMAD SHUKRI YAHAYA, NOR AZAM RAMLI, JANNATUL NAEMAH MOHAMED SEDEK

School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Seberang Perai Selatan, Pulau Pinang, Malaysia.
shukri@eng.usm.my

School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Seberang Perai Selatan, Pulau Pinang, Malaysia.
ceazam@eng.usm.my

School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Seberang Perai Selatan, Pulau Pinang, Malaysia.

Abstract The rapid growth of Kuala Lumpur had caused pollution and degradation of urban environment quality. Air pollution is the major issue that has been affecting human health and building quality. This paper analyse one of the pollutants namely carbon monoxide (CO) in Kuala Lumpur. The data consist of 8760 observations taken every hour for a year. According to the Malaysian Ambient Air Quality Guideline, the concentration of CO for eight hours should not be more than nine parts per million (ppm). Thus three states were chosen that is when the CO concentration is (a) high (b) medium and (c) low. Using the transition matrix of the first order Markov Chain, the steady state distributions were obtained. The result shows that, at steady state, the probability that the CO concentration in Kuala Lumpur is high, medium and low, is 0.051, 0.231 and 0.718 respectively.

Keywords: Markov chain, steady state.

1. Introduction

Monitoring data and studies on ambient air quality show that some of the air pollutants concentrations in several large cities such as Kuala Lumpur, Malaysia are increasing with time and are not always at acceptable levels according to the national ambient air quality standards. The goal of achieving industrial country status by the year 2020 and the associated rapid economic growth begin to impose costs in terms of human health and reduction in the quality of urban environment. Depreciation of air and water quality, and contamination by industrial wastes has become more serious in Kuala Lumpur in recent years. Among them, air pollution is the major issue and need to be dealt with before it causes more and irreversible harm to human health and the environment.

From the geographical point of view, Kuala Lumpur which is situated in a valley, namely the Klang Valley is prone to serious air pollution compared to other parts of the country. This is due to the tendency of pollutants to be trapped in valley like corridor is higher.

Gokhale and Khare (2004) review the different models that can be used in air quality studies. They classified air quality models into four different types' namely deterministic, statistical, statistical distributions and hybrid. Fourteen models were presented and all models can be used to predict CO concentrations with some models having higher predictive accuracy than others. Among the models used was the Markov-type model which was developed by North *et al.* (1984) based on up and down crossings of threshold concentrations of series of daily CO concentration in Madrid, Spain.

This paper discusses the use of the Markov chain to predict the concentration of CO when steady state is considered. Steady state is expected to occur if all other factors are assumed to be constant.

2. The Data

The data used for this analysis is the hourly carbon monoxide (CO) data (measured in parts per million, ppm) for the year 1998 taken at a monitoring station in the Federal Territory of Kuala Lumpur. Kuala Lumpur was chosen because it has the highest growth rate in transportation, utilities and manufacturing activities. As a result the deterioration of air quality is more serious in Kuala Lumpur compared to other parts of the country. Table 1 below describes the data.

Table 1. Descriptive statistics of CO data

Number of observations	7939
Number of missing observations	821
Mean	2.33
Standard deviation	1.88
Minimum	0
Maximum	14.03

From Table 1, it can be seen that there are 821 missing observations which accounts to about ten percent of the data. The missing data occurs mostly in lengths of about two or three hours. The mean imputation technique was used to replace all missing values. The method with the mean of one datum above the missing value and one datum below the missing value was used. Table 2 below describes the data after the mean imputation technique was used.

Table 2. Descriptive statistics of CO data after the mean imputation technique was used

Number of observations	8760
Number of missing observations	-
Mean	2.27
Standard deviation	1.86
Minimum	0
Maximum	14.03

3. Markov Chain

Consider a system that can be in any of a finite number of states, and assume that it moves from state to state according to some prescribed probability law. The system, could record the concentration of pollution from day to day, with the possible states being highly concentrated, medium concentrated and low concentrated. Observing the condition over a long period of time would allow one to find the probability of being highly concentrated tomorrow given that it is low concentrated today. This system is called Markov Chain (Scheaffer, 1995). Hines *et al.*, (2003), defined the Markov Chain as a stochastic process that exhibits

$$P\{X_{t+1} = j / X_t = i\} = P\{X_{t+1} = j / X_t = i, X_{t-1} = i_1, X_{t-2} = i_2, \ldots, X_0 = i_t\} \quad (1)$$

for $t = 0,1,2,\ldots$ and every sequence $j, i, i_1, \ldots, i_t$.

The conditional probabilities

$$P\{X_{t+1} = j / X_t = i\} = P_{ij} \quad (2)$$

are called one-step transition probabilities, and are said to be stationary if

$$P\{X_{t+1} = j / X_t = i\} = P\{X_1 = j / X_0 = i\} \quad \text{for } t = 0,1,2,\ldots \quad (3)$$

so that the transition probabilities remain unchanged through time. They are denoted as the transition matrix $P = \lfloor p_{ij} \rfloor$, called the one-step transition matrix. The matrix P has $m+1$ rows and $m+1$ columns, and the sum of probabilities in each row of the transition matrix is one.The existence of the one-step stationary transition probabilities implies that

$$P_{ij}^{(n)} = P\{X_{t+n} = j / X_t = i\} = P\{X_n = j / X_0 = i\} \quad (4)$$

for all $t = 0,1,2,\ldots$. The values $P_{ij}^{(n)}$ are called n-step transition probabilities, and they may be displayed in an n-step transition matrix, $P^{(n)} = \lfloor p_{ij}^n \rfloor$.

The Malaysian ambient air quality guideline (Department of Environment, Malaysia (1998)) states that for CO, the concentration for 8 hours should not be more than 9 ppm. Thus the data set for CO have been recorded as shown in Table 3.

Table 3 : Recoded CO data

Recoded data	Concentration (ppm)
High	> 6.01
Medium	3.01 – 6.0
Low	0.0 – 3.0

4. Results and Discussion

Figure 1 below shows bar chart for the hourly CO concentrations for the year 1998 in Kuala Lumpur. It can be seen that about 73% of the time the CO concentration in Kuala Lumpur is low and only about 4.7% of the time that the CO concentration in Kuala Lumpur is high.

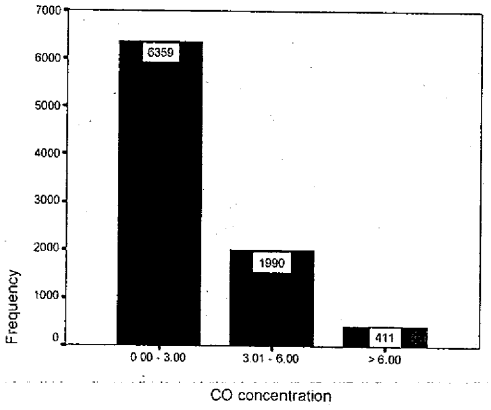


Figure 1. Bar chart for hourly CO concentration in Kuala Lumpur (1998)

Based from the definition of the Malaysian ambient air quality guideline, the transition matrix of the first order Markov Chain model was obtained and is given by

$$P = \begin{array}{c} \\ H \\ M \\ L \end{array} \begin{array}{c} \begin{array}{ccc} H & M & L \end{array} \\ \begin{pmatrix} 0.760 & 0.210 & 0.030 \\ 0.290 & 0.532 & 0.177 \\ 0.078 & 0.388 & 0.534 \end{pmatrix} \end{array} \tag{5}$$

From the first order Markov Chain model, the probability that the CO concentration is high today given that it is high yesterday is 0.760 and the probability that the CO concentration is low today given that it is high yesterday is 0.078.

The n-step transition matrix will provide the steady state probabilities for CO concentration and the time taken to reach the steady state. Steady state is assumed to occur if the CO concentrations are constant over time. From the analysis, it was found that steady state occurs at $n = 14$ days and with the n-step transition matrix given by

$$P^{14} = \begin{bmatrix} 0.048 & 0.227 & 0.727 \\ 0.048 & 0.227 & 0.727 \\ 0.048 & 0.227 & 0.727 \end{bmatrix} \tag{6}$$

Therefore, the concentration of CO in Kuala Lumpur will reach steady state after 14 days and the steady state probabilities are as given in the n-step transition matrix above.

7. Conclusion

This paper discusses a stochastic method called Markov Chain to predict the probability of occurrences of high, medium and low CO concentrations for the year 1998 in Kuala Lumpur. The CO concentrations were recoded according to the Malaysian ambient air quality guideline which states that for CO, the concentration for 8 hours should not be more than 9 ppm. From the first order Markov Chain model, it can shown that the probability that the CO concentration is high today given that it is high yesterday is 0.760 showing the dependency of CO concentration on what happens on the previous day. It was also found that steady state would be reached after 14 days and the steady state probabilities are 0.048, 0.227 and 0.727 for high concentration of CO, medium concentration of CO and low concentration of CO respectively. Thus, it can be concluded that the CO concentration in Kuala Lumpur is still low.

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A STUDY TO DEVELOP A METHOD TO REVIEW EIA REPORTS

Azianabiha A. Halip & Nor Azam Ramli
School of Civil Engineering,
USM Engineering Campus,
14300 Nibong Tebal, Penang

ABSTRACT

In Malaysia Environmental Impact Assessment (EIA) is mandatory under the section 34(A) Environmental Quality Act 1974. The EIA must be critically evaluated or reviews to ensure the EIA report has sufficient reliable information to understand the likely environmental effects before the planning application is approved. A software based review method was developed and can be used by decision maker to approve a project. The basic concept for this review method was to identify the interaction between project activities and environmental characteristics within a matrix. The appropriate matrix cell is scored for potential impact magnitude and significance. Infrastructural works was identified as the most critical stage with the average of 96.3 points, site formation with 91.2 points, site clearance with 83.8 points and construction of site facilities with 69.2 points. Result from the review process conducted in this research shows that the noise quality was still not properly addressed EIA reports. 8% of housing projects had no noise monitoring station and 84% fail to use the noise standard as required by DOE. 89% of housing project described noise quality monitored using quantitative methods. Noise impact identification and prediction was poorly explained with 20% of housing projects gave an inadequate explanation. Besides, only 39% the projects provide adequate noise mitigation measures in their EIA reports. From the reviewed process carried out in the research it can be concluded that noise quality were still not properly tackled in EIA reports. This problem should be considered by decision maker and the development of this software based review methods will be very useful for assessment panels in making decision on EIA reports.

INTRODUCTION

Environmental Impact Assessment (EIA) can be defined as a systematic identification and evaluation of the potential impact (effects) of proposed projects, plans, programmes or legislative actions relative to the physical-chemical, biological, cultural, and socioeconomic components of the total environment. The primary purpose of the EIA process is to encourage the consideration of the environmental planning and decision-making and to ultimately arrive at actions which are more environmentally compatible (Canter 1996).

An EIA report is normally reviewed once it has been completed, before being submitted to the decision-making authority. The main purpose of the review is to verify that

the information and conclusions presented in the EIA report are sufficient for informed decision making. This is to ensure the planning authority has sufficient reliable information to understand the likely environmental effects and mitigation measures before the project is implemented. In most countries, the formal review is undertaken by a governmental environmental review agency. The results of the review are then passed on to another agency for ultimate approval of the development project (Lohani et al. 1997).

However, there exists very little guidance in the EIA literature for practitioners concerning EIA decision-making processes. Subsequently, the performance of EIAs based on expert judgment is often less than satisfactory, and quality improvements are required in the EIA review process. Thus, this research has developed a review method that outlines a number of principles concerning EIA decision-making, and attempts to provide some guidance for practitioners in this regard.

Noise Quality in EIA Reports

Noise quality issue is also a major concern in preparing an EIA report. In order to determine the compliances of the methods used in EIA reports with the standard guidelines, an inventory of the methods used for noise monitoring in EIA reports was established. The trend was then compared with standard guidelines as required by DOE. The description on impacts and mitigation measures for noise quality in EIA was also reviewed.

METHODOLOGY

The methodology is divided into two parts. The Stage 1 methodology involved the choice of EIA reports to be reviewed, the review of the quality of EIA reports, the analysis of the EIA, report review results and the outcome of the assessment. Stage 2 of the research required a critical study to enable findings for a modification of the reviewing process and procedures.

This study focus only on noise quality issues, hence the related sections of the EIA reports were investigated, i.e. monitoring methods, impact prediction and identification and mitigation measures. In total, 80 EIA reports from housing projects were selected for review. The number of EIA report quality assessments was considered to be sufficient to enable meaningful conclusions about trends in EIA quality to be drawn, thus meeting the purpose of this study.

The second stage of this study was to develop review software that can be used to review EIA reports. The review software was developed using Excel by digitizing a matrix that can be utilized by reviewer. The matrix summarizes and displays the interactions between a list of project activities and environmental characteristics. If the project activities were recognized to have an effect on an environmental characteristic, the appropriate matrix cell is scored for potential impact magnitude and significance. For each cell in the matrix, a ranking system (scaled from 0 to 3) is given. Then the total score for environmental characteristic was then calculated at the right ends of the matrix, while the bottom end of the matrix columns contains the total score values for each project activities.

No guideline was used for the evaluation of significance. The evaluation of importance was based on the value of self-judgment based on the literature made. The reasoning behind the assignment of values for magnitude and importance would be provided. The review process can be made by introducing a comment in the cells to highlight impact severity or other features related to the nature of the impact. For a factor that had scored more than 11 points along the project activity, it was then considered as a significant factor. Meanwhile, for a project activity to be considered as significant, the overall points scored must be more than 60.

RESULTS AND DISCUSSION

Result of Reviewed EIA Reports

A wide variety of methods are available for measuring noise quality with an equally as wide variation in cost and precision. Specific monitoring methods should be chosen, taking into consideration the purpose and objectives of the monitoring program. It is important to use the method that complies with the standard method or recommendations. This section will discuss the outcome of the review process that was done in stage one of this study which focused in noise quality monitoring reviewed in each EIA reports.

Noise Quality in Housing Projects

Figure 1 shows that 68% of the housing projects that have been reviewed were between 0 to 99 hectares while 16% of the projects were between 100 to 199 hectares. 5% of the projects were varying from 200 to more than 299 hectares. This information is important since it showed the area consumed by the projects and would be useful to determine the number of data collection, monitoring stations and parameters that should be conform by the project proponent.

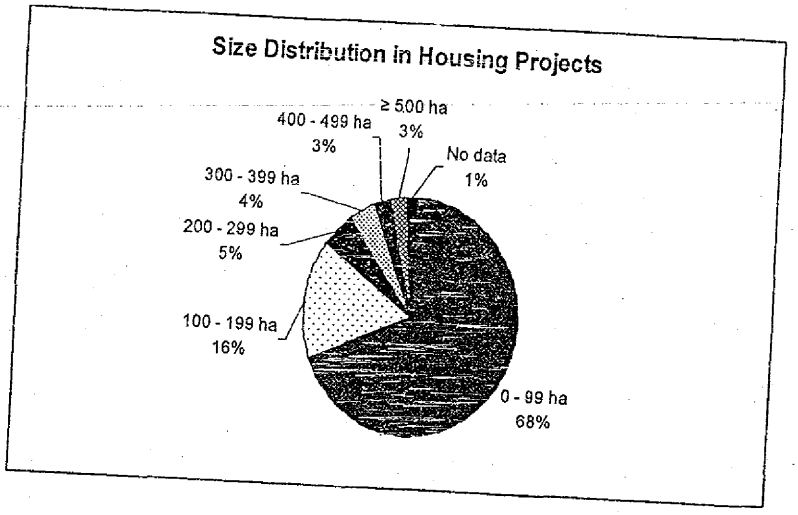


Figure 1. Size distribution in housing projects

Figure 2 shows the number of monitoring station that is used for noise monitoring at each of the housing projects that have been reviewed. Most of the site, which consist a significant 47% of the projects have two stations for noise monitoring process and 20% of the projects have only one station. 8% of the projects did not mention the number of noise monitoring station that being set up at their project site. There were only 3% of projects that have more than five noise monitoring stations. This percentage is very low and steps should be taken to ensure noise-monitoring study is properly conducted at the project sites and would produce an accurate result. As for evaluation on number of stations and the respective size of the project, Table 1 shows the size housing project in term of percentage with their respective number of monitoring station at the project site.

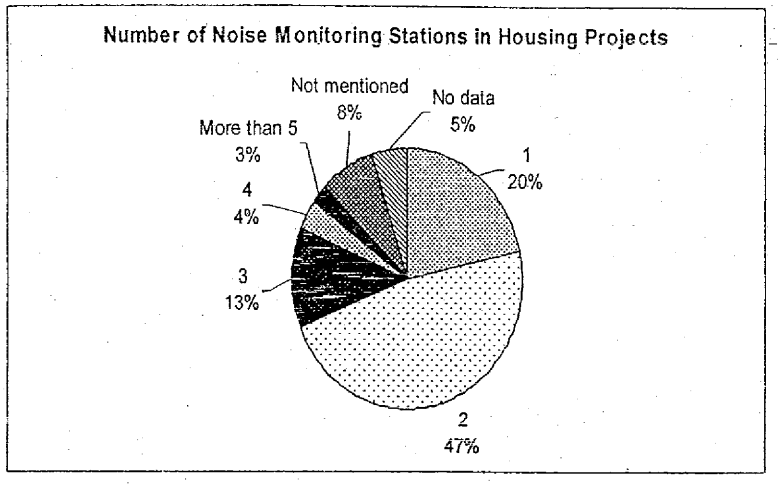


Figure 2. Number of noise monitoring stations in housing projects

Table 1. Number of noise monitoring stations with the respective project size for housing projects

Monitoring Stations	Size of projects (Ha)						Total (%)
	0-99	100-199	200-299	300-399	400-499	> 500	
1	11	8				1	20
2	35	3	5	3		1	47
3	5	7			1		13
4	4						4
≥ 5	1	1	1				3
Not Mentioned	6	1			1		8
No data	4	1					5

Noise monitoring methods in Malaysia are complying with the guidelines issued by the DOE (2004). In the guidelines, noise monitoring should be at the nearest noise sensitive premises and the best position for the monitoring points will often be outside the sensitive premises at the real property boundary. In a case of housing project, the noise monitoring station should be located at the nearest community area which the residents would be the sensitive receivers. The number of noise stations must be enough to cover all strategic locations representative of the entire project boundary and at all locations affecting the community.

In Malaysia, noise measurement shall be made with a precision sound level meter which complies with the requirements of the International Electrotechnical Commission (IEC) Publications 60651, 60804 and 61672 or thereafter, for the type of meters in Class 1. Measurement for statistical centile levels (L_{10}, L_{90}) and maximum instantaneous level (L_{max}) shall be made using a sound level meter installed with statistical analysis functions. At least three measurements should be carried out at each measuring locations. However, for continuous monitoring over a complete 24 hours cycle (for day and night time L_{Aeq}) a single continuous 24 hours measurement per measuring locations is often acceptable if the noise source generation at the day of measurement is deemed representative of source(s).

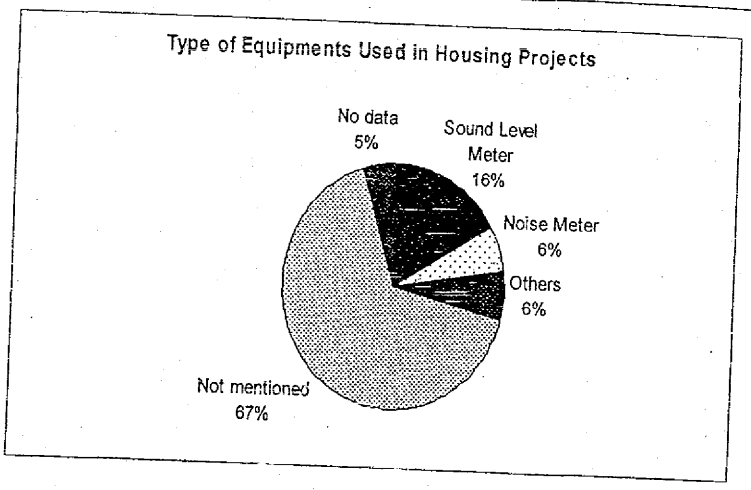


Figure 3. Equipment used for noise monitoring in housing projects

Figure 3 shows the variety of instruments that have been used in the noise monitoring process in the housing projects. Most of the projects with 67% of the total number did not mention the types of equipment they used. However, the most frequently used instrument was sound meter with 16% of the projects which comply with the mentioned standard. Beside that, this was maybe due to the fact that this equipment can be easily managed and can produce an accurate result. Noise meter was used by 6% of the projects. 5% of the projects do not have any noise quality monitoring hence no equipment have been utilized.

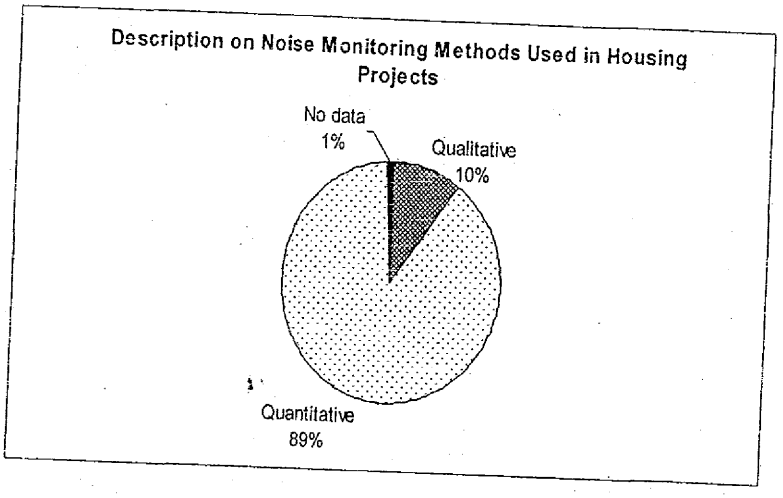


Figure 4. Description of noise monitoring methods in housing projects

There are a couple of approaches to give description on the noise quality that has been monitored. There are quantitative descriptions which indicate the value of the noise monitored and qualitative descriptions which only gave the standard of the monitored values such as high and low. As shown in Figure 4, 89% of the projects presented the noise quality quantitatively and 10% of the projects provided the data in qualitative method. The other 1% of the projects did not carry out noise monitoring at their sites.

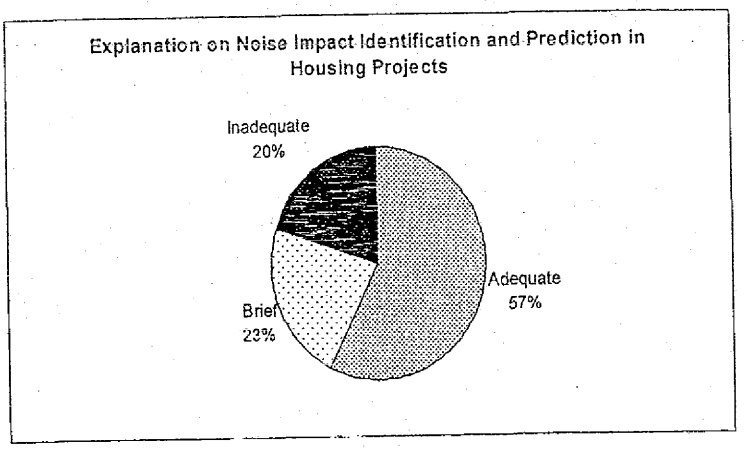


Figure 5. Explanation on noise impact prediction in housing projects

Impact prediction study is very important to anticipate the potential impacts to the existing environment which will take place from the implementation of the proposed projects. Thus it is very crucial that this stage is properly executed not only to know the extent of the impact but also to assist in deciding the necessary mitigation measures.

As in Figure 5, 57% of the housing reports may be classified as adequate which means it covered the explanations of the sources and effect that are predicted from impact that is expected. While 23% of the reports can be classify as brief because it provided insufficient details about the impact sources or effect. 20% of the reports are categorized as inadequate where these reports offer very briefly on sources and effects of the impacts.

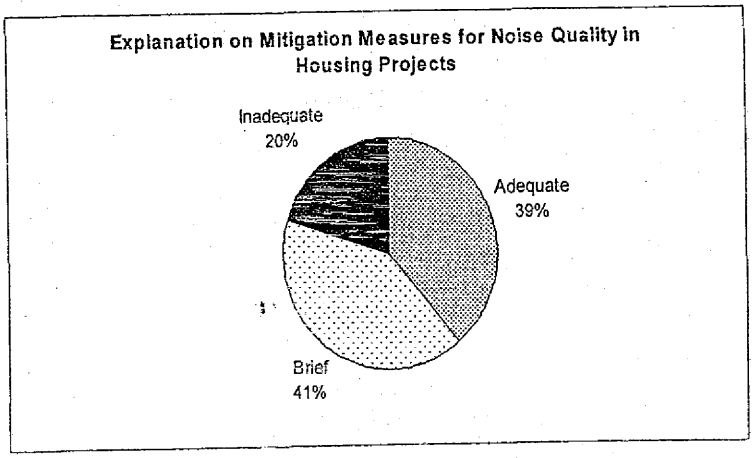


Figure 6. Explanation on noise mitigation measures in housing projects

In every report, a section of mitigation and abatement measures should discuss all the design measures that have been adopted into the project plan to reduce or to eliminate significant potential environmental impacts.

From Figure 6, the explanation for noise mitigation measured was classified as adequate if the reports have sufficient details and descriptive explanation. From 80 housing projects, 39% provided adequate information on their mitigation measures, 41% presented a brief clarification where the reports listing the most common measures. The other 20% gave

an inadequate explanation which addressing the mitigation measures very briefly by indicating some mitigation measures that should be taken. Table 2 shows the summary of mitigation measures for noise impacts in housing projects.

Table 2. Summary of mitigation measures for noise pollution in housing projects

Mitigation Measures	No. of Project
It will be necessary to limit working hours to daylight hours only especially for those activities like piling and rock crushing which generate much noise. Construction activities shall not be permitted after 7.00p.m	69
The employer must provide the workers with hearing protection devices (HPD) and ensure that they are worn properly during the duration of their work shift and while operating the machines equipment.	25
Noise generate by increase traffic during construction could be reduced by controlling the speed of the vehicles entering the project site.	33
Monitor noise level along the border of the construction site so that immediate control measures will be taken if the immediate noise level exceeds the limits.	4
Attenuation by natural barriers and trees could lower the noise level considerably.	38
Sufficient buffer between the source of noise and the recipient. Buffer zones should be provided along the boundary of the project	35
Assure the factories will be light industries. Locate the industrial or commercial areas as far as possible.	4
Using low noise pollution machinery and equipment.	12
Practice the environmentally friendly cast-in-site bore piling method. Choose appropriate piling system to reduce noise impact such as "Hydraulic Injecting" System or "Cast In Site" system.	28
The reduction of noise can be achieved by the use of acoustical barriers	11
Transportation of construction machinery and materials will be carried out only during off-peak hours so is not to impede the normal flow of traffic.	3
Practicing a good blasting design. For example, a 'Delay Blasting Technique' by using delayed detonators is strongly recommended to avoid excessive noise and vibration impact during blasting.	6
Reduce workflow by employing more workers/specialist operating such investigation.	2
Construction of hoarding surrounding the project boundary that will alleviate to some extent the noise generated within.	23
Exhaust muffing of all moving machineries should be provided.	9
Noise pollution can further be reduced through the careful selection of glazing, window type and design	2
The noise level during site clearing and construction can reduced if this activities are managed properly and carried out phase by phase.	4
Maintain the reuse of construction material and minimize waste generation.	1
Ensure that all equipment and vehicles are in proper working condition so as to minimize the amount of noise generated.	29
Routes to be used by construction traffic must be agreed with designated authority. This is to ensure smooth transport system that subsequently will reduce noise.	7
If possible, any activities that produce earsplitting noise should be confined in a working shack.	1
Warning signs should also be installed at high-level noise areas to alert workers of the noise danger.	7
Minimize number of heavy vehicles that is allowed to use the main access.	4
Material stockpiles and other structure should be properly utilized to screen receivers from noisy onsite construction activities.	3

Minimize working area.	1
Machines and plant that maybe in intermittent use should be shutdown between work periods or should be throttled down to a minimum.	4
Plant known to emit noise strongly in one direction should where possible be oriented so that the noise is directed away from receivers.	3
Locating the noisy machinery such as generators as far away as possible from residential areas.	8
The use of appropriate road surface (preferably paved road) to minimize noise.	1
Use larger and slower equipment that will reduce overall noise generation during operation.	7
Control of explosive used in blasting. A correct quantity to be ensured for a given blasting size.	2
Changing to another machine, altering the design, construction or installation.	1
Sounding of warning prior to blasting.	2
Use suitable stemming materials such as chipping.	1
Blasting noise can be reduced by favorable weather conditions (clear skies, warm temperature).	1

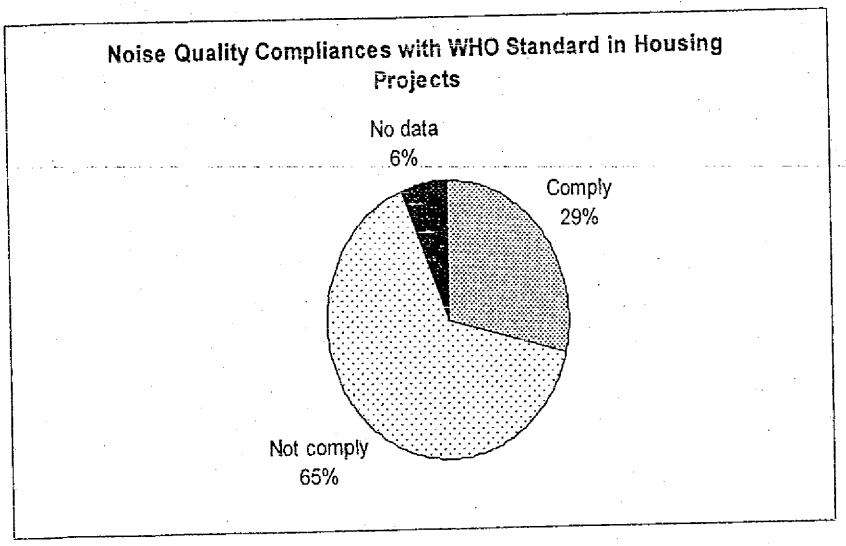


Figure 7. Noise quality compliances in housing projects

In this research, the noise quality data that were provided in the reports are compared with World Health Organization (WHO) standard. Each values of noise quality monitored are checked if it is within the recommended value. The noise level for each day and night must comply with the WHO standard and if it is not, an appropriate impact prediction study and mitigation measure should be analyzed.

Figure 7 shows that 65% from 80 housing projects, are complying with the standard which is very encouraging as for noise quality is concerned. But there were also 29% of the project that does not meet the standard.

According to DOE (2004), for compliance verification and record keeping, the monitoring of noise quality in the project site should be undertake by the project proponent everyday for a minimum period of two weeks. However, from the EIA reports reviewed, many of the housing projects did not followed this guideline where the noise monitoring duration only been carried out on a certain period time.

CONCLUSION

The review method used in this research is based on established methods with the modification on the approach on how the EIA evaluation should be made. A software based review method in the form of matrix was developed and can be used to identify the interaction between project activities and environmental characteristics. The matrix can be used by introducing a score in the cells to highlight impact severity related to the nature of the impact. This research concluded that noise quality issue was still improperly addressed in EIA reports. There was still lack of information provided in the EIA on this issue to enable a precise impacts prediction study and the appropriate mitigation measures. The preparation of EIA and the methods used must comply with the standard guidelines in Malaysia. These issues must be seriously considered before the EIA reports are accepted to ensure the objective of EIA in protecting the environment is well served.

On the other hand, based on the EIA reports from housing projects that has been analyzed using the matrix, construction phase which consist activities such as site clearance, construction of site facilities, site formation and infrastructural works was the most crucial stage in term of impacts to the environment. The impact was also significant in pre-construction phase especially during land acquisition process. As for environmental characteristics were concern; attributes such as land use, landforms, soil profile and water quality were most affected by the project development. Therefore, these mentioned project activities and the related environmental criteria affected must be thoroughly discussed in the EIA reports. The comprehensive and reliable information about these likely environmental effects and sufficient mitigation measures should be explained in the EIA report before the project is approved.

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A STUDY ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF AIRBORNE PARTICULATE MATTER IN DEVELOPING TOWN (CASE STUDY IN PARIT BUNTAR AND NIBONG TEBAL)

Abdul Haqi Ibrahim, Nor Azam Ramli & Wan Hashim Wan Ibrahim
School of Civil Engineering,
Universiti Sains Malaysia,
14300 Nibong Tebal, Penang

ABSTRACT

This research investigates the physical and chemical properties of airborne particulate matters (PM) in Parit Buntar and Nibong Tebal. Non-reactive carbon layer is glued onto a stub to collect airborne particulate matters from the atmosphere. The stub was exposed to the ambient atmosphere for 24 hours to allow the particulate matter to deposit onto it. PM sample from vehicles exhaust also being collected and analyzed in order to see the association between the vehicles as a source of particulate matter. The stubs then are placed directly into the Scanning Electron Microscope (SEM) to analyze their images. Chemical compositions of those particulate matters are being analyzed using Energy Dispersive X-ray equipment that is presences as an accessory to the SEM. The electron microscope (SEM) used was a Leo Supra 50 VP while Energy Dispersive X-ray equipment used was Oxford Inca 400. From the research, it was found that the greatest contribution to PM mass collected in Parit Buntar are carbon (organic carbon or/and elemental carbon), O, Al, Si and other species such as Ca, K, Fe and Mg. These elements probably come from earth crust mineral and particles from vehicles exhaust as well as factories nearby. While the size is varies from 7.9μm to 158μm and can be categorized as coarse particles.

INTRODUCTION

Cities and towns are always being picture as abundant of populations, activities and materials. They therefore show the highest level of air pollution and being the largest target of impact. This phenomenon becomes worse with the presences of industrial areas around the town. Uncontrolled stacks emission from factories can also contribute to bad air quality to the town atmosphere. Construction activities, especially the dust from the construction sites and vehicles emission are sources that polluting the town atmosphere.

Air pollution is the important point of our concern because it affects people, ecosystem, plant, and building and monumental stones adversely. Air pollution can be define as changed of air quality by addition of particles, gases, or energy forms (e.g. heat, radiation or noise) so that the altered atmosphere poses some harm (Godish 1997).

In Malaysia, there are three main sources of air pollutants; mobile sources, stationary sources and open burning sources (Afroz et al. 2001). These sources emit varies of air pollutants such as carbon monoxide (CO), sulphur dioxide (SO_2), particulate matters (PM) and etc. However, in Malaysia, five pollutants have been categorized as criteria pollutants and being monitor continuously. These five air pollutants are carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxides (NO_2), ozone (O_3) and particulate matter below than 10μm in size (PM_{10}) (DOE 2002).

Health impact due to air pollution exposure can be divided into two categories namely short-term and long-term effect. Short-term effects occur when the pollution level is very high and end with acute condition. However, long term effects are unknown and hard to trace. Some pollutants are carcinogenic and the effects appear only after a few years of exposure. The result can be more serious for children, for whom the particulates inhaled relatively high to body size (Afroz et al. 2001).

Researches have constantly demonstrated bad effects of particulate matter exposure on human health. The studies show that exposure to airborne particulate matter is connected with an increase incidence in both respiratory and cardiac disease. Although the affect of particulate matter to human health is given priority, the negative effects on plant, ecosystem, building and monumental stones should not be neglected.

During the haze episode in September 1997, researchers found that particulate matter contributes most of the haze component compared to gases. During the episode, number of patient suffer to respiratory problem had increased. As an example, in Kuala Lumpur, patient came to get treatment because of respiratory problems has increased from 250 to 800 per day while in Kuching, the number of patient increased two to three times during the peak time of smoke haze (Afroz et al. 2001).

However, in this research, not all air pollutants being studied. Only particulate matter is given a consideration. Sample of particulate matters were collected and being analyzed to gain information of its chemical compositions and images. Research should be carried out intensively in order to build our knowledge in this area, thus give us more idea to handle this problem. One of the great issues is whether the chemical or physical properties are important for its effect on health (Harrison & Yin 2000).

EXPERIMENT

Particle Sampling from Area of Interest

In this project, particulate matters from the ambient atmosphere of Parit Buntar have been studied. The following sampling methodology was carried out to collect sample from the atmosphere:

- Particles deposited on horizontal non-reactive surface (carbon layer) sheltered from rainfall. Figure 1 shows the non-reactive carbon layer that later being glued onto studs while Figure 2 shows the aluminium stubs.

Particles deposited on these carbon surfaces in a continuous way. These studs were exposed to the ambient atmosphere for 24 hours to allow the particulate matter to deposit onto it. The stubs were placed about 1.5m from the land surface. Stubs that have been exposed to the atmosphere for 24 hour are then being stored in petri dish and ready to be analyzed.

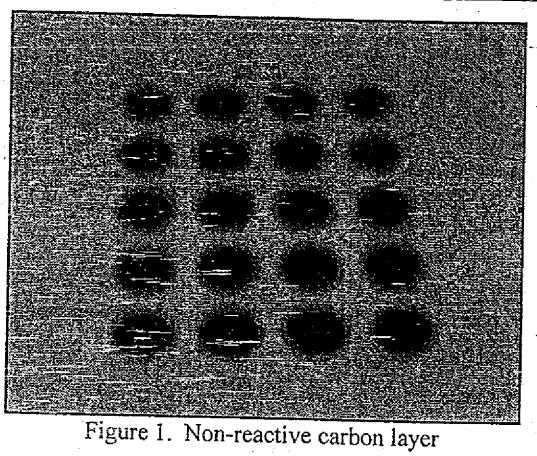


Figure 1. Non-reactive carbon layer

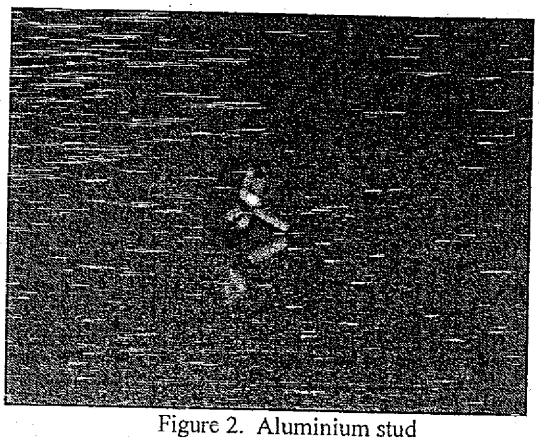


Figure 2. Aluminium stud

Sampling site categories

In order to do sampling, site of sampling are divided into two categories (Table 1). Those categories are:

- Type 1: Urban site.
  Locate stud in the central business district of the urban area on a congested, downtown street surrounded by buildings and having many pedestrians.
- Type 2: Suburban site.
  Locate stud out of central business district of the urban area but quite close to major streets.

Table 1. Sampling sites locations in Parit Buntar

PARIT BUNTAR	
Urban site	Rural site
Pusat Bandar (PUSAT BANDAR)	Kilang padi (KILANG PADI)
Pekan Lama (PEKAN LAMA)	Kompleks Sekolah (KOMPLEKS SEKOLAH)
Pekan Baru (PEKAN BARU)	Simpang Empat Taiping – Parit Buntar (SMPG4 TAIPING – PB)
Clock Tower (CLOCK TOWER)	Sempadan Perak – Pulau Pinang (PRK-PP)
Hotel Damai (HOTEL DAMAI)	Majlis Daerah Kerian (MDK)

Instrumental technique

X-ray mapping by SEM-EDX have been carried out in all the cases (particle bulk analysis). The electron microscope (SEM) used was a Leo Supra 50 VP while Energy Dispersive X-ray equipment used was Oxford Inca 400. A scanning electron microscope (SEM) is used to observe the physical appearance and to record the digital images of the particles samples while EDX is use to analyze the chemical composition of the particulate matters. Before samples being put into the SEM-EDX to be analyze, those samples were coated with Aurum (about 20 nm thick) using sputter coater, Polaron SC 515.

RESULTS AND DISCUSSION

Table 2 shows the elements presence in the particles. It is arranged in table manner to make it easier to identify the differences or similarities between the particles. Before the research being carried out, the hypothesis is that there are heavy metal presences as a main element in the particulate samples collected in Parit Buntar and Nibong Tebal. However, this research shows that heavy metals are not the main elements of the particulate.

Wu et al. (2003) mentioned that the greatest contribution of coarse paticles in urban and rural areas are organic carbon, elemental carbon, sulfate, nitrate, ammonium, Na, Cl and geological species such as Si, Ca, Al, Fe, K and Mg.

From the result obtained, it is believed that most of the particles are from the earth crust. There are few points that make this statement make sense. The elements presence in all particles are closely same with the elements presence in the earth crust. There are 10 most abuntant elements in earth crust namedly oxygen, silicon, aluminium, iron, calsium, sodium, magnesium, potassium, titanium and hidrogen with the percentage of weight 46.1%, 28.2%, 8.23%, 5.63%, 4.15%, 2.36%, 2.09%, 0.565% and 0.14% respectively.

50 out of 60 samples contain Al and 55 out of 60 samples contain Si while O present in all samples (refer to the Table 2 and 3). O is very reactive with other elements. O bond as an O^{2-} anion to form compound called oxides. Other crustal species as mentioned above also presence in the sampel randomly. Mineral which combine Si and O elements are called silicates, and the combined are the most abundant minerals on the Earth. This point gives strong evidence that most of these particles are silicate minerals. Those particles could be olivine $(Mg,Fe)_2SiO_4$, Augite $(Mg,Fe)SiO_3$, Hornblende $Ca_2(Fe,Mg)_5Si_8O_{22}(OH)_2$, Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$, Muskovite $KAl_2(AlSi_3O_{10})(OH)_2$, orthoclase $KAlSi_3O_8$, Plagioclase $(Ca,Na)AlSi_3O_8$ and quartz SiO_2. By looking to the empirical formula, it is possible that particles collected are probably silicate mineral. All elements can be seen present in the particles collected in Parit Buntar and Nibong Tebal.

At Kilang Padi sampling area, rice husk ash may also contribute particulate matter rich in Si content. Rice husk ash contains about 85% Si. The size of rice husk is small, about 25 μm in diameter. This ash can be transported from the factory area to places nearby.

Earth crust materials present in the air by certain action. Earth works at construction site contribute most of the presences of soil dust wind blown rock-derived material in the atmosphere. Dry surface and high wind speed tend to be favoured the suspension of these earth crust materials in the air. Construction work near the sampling site is one of the examples how crust material was introduced into the atmosphere. Construction site near Sekolah Kebangsaan Transkerian is one of them.

Beside that, these crust elements also become resuspended due to the action of the wind turbulence induced by passing road traffic. Asphalt road pavement and concrete pavement contain crustal mineral as one of the component. Asphalt road contains quatz (SiO_2), calcite ($CaCO_3$), asphalt and iron oxide (FeO). Mean while concrete pavement is mixed of limestone aggregate ($CaCO_3$), iron oxide (FeO) and cement.

Table 2. Elements in particles collected in Parit Buntar

LOCATION	ELEMENTS													
	Al	Ca	Cl	Cu	Fe	K	Mg	Na	Si	S	Ti	C	O	Zr
KILANG PADI														
spot 1	*					*			*			*	*	
spot 2	*				*							*	*	
spot 3	*					*		*	*			*	*	
KOMPLEKS SEKOLAH														
spot 1	*				*	*	*		*			*	*	
spot 2	*				*			*	*			*	*	
spot 3	*	*	*		*		*	*	*	*		*	*	
PEKAN BARU														
spot 1	*				*				*			*	*	
spot 2				*	*				*	*	*		*	
spot 3	*				*	*		*	*			*	*	
PEKAN LAMA														
spot 1	*				*	*	*		*			*	*	
spot 2	*					*			*			*	*	
spot 3	*				*				*			*	*	
PUSAT BANDAR														
spot 1		*					*		*	*		*	*	
spot 2	*				*		*		*			*	*	
spot 3	*					*			*			*	*	
CLOCK TOWER														
spot 1	*	*							*			*	*	*
spot 2	*							*	*			*	*	
spot 3	*	*						*	*	*		*	*	
HOTEL DAMAI														
spot 1	*					*			*			*	*	
spot 2									*			*	*	
spot 3	*					*		*	*	*			*	
MDK														
spot 1	*	*				*			*			*	*	
spot 2	*				*		*		*			*	*	
spot 3	*								*			*	*	
PRK -PP														
spot 1					*				*	*	*	*	*	
spot 2			*		*							*	*	
spot 3	*				*	*	*		*			*	*	
SMPG4 TAIPING-PB														
spot 1	*				*		*		*			*	*	
spot 2	*								*			*	*	
spot 3	*				*				*			*	*	

* Element presents in particle

Table 3 shows the size of each particle that had been analyzed using Scanning Electron Microscope (SEM).

Table 3. Size of particles

Samples from Parit Buntar	Size (µm)	Samples from Nibong Tebal	Size (µm)
KILANG PADI		SEK TRANS	
Spot 1	129	spot 1	14.1
Spot 2	114.5	spot 2	8.3
Spot 3	125.8	spot 3	7.9
PUSAT BANDAR		JAWI	
Spot 1	35.6	spot 1	53.3
Spot 2	33.3	spot 2	19.7
Spot 3	36.5	spot 3	4.8
PEKAN LAMA		PB. N TEBAL	
Spot 1	71.9	spot 1	19.4
Spot 2	42.6	spot 2	7.5
Spot 3	58.05	spot 3	7.5
PEKAN BARU		SG BAKAP	
Spot 1	49.5	spot 1	65
Spot 2	101.6	spot 2	8.9
Spot 3	38.13	spot 3	9
KOMPLEKS SEKOLAH		P. KELING	
Spot 1	23.07	spot 1	30.8
Spot 2	15.7	spot 2	10.4
Spot 3	13.8	spot 3	25.3
SMPG4 TAIPING-PB		MAYBANK NT	
Spot 1	72	spot 1	77.4
Spot 2	48.7	spot 2	33.5
Spot 3	35.2	spot 3	158.05
PRK-PP		SM TEKNIK	
Spot 1	58.8	spot 1	71.1
Spot 2	42.2	spot 2	77.4
Spot 3	91.7	spot 3	36.3
HOTEL DAMAI		TEPI SUNGAI	
Spot 1	106.5	spot 1	290.3
Spot 2	86.7	spot 2	77.4
Spot 3	38.1	spot 3	60.5
MDK		SM SRI NIBONG	
Spot 1	110	spot 1	25.9
Spot 2	82.2	spot 2	77.9
Spot 3	82.2	spot 3	222.6
CLOK TOWER		TELUK IPIL	
Spot 1	27.2	spot 1	75.5
Spot 2	94.45	spot 2	85.5
Spot 3	32	spot 3	74.1

Beside the crust material, other components may contribute to the chemical element of those particles. Fine particles may attach to the particles and make up the chemical elements of the particle. Particulate matter from the vehicles exhaust are much finer compare to the crustal material presences in the atmosphere and it is possible to attach to the coarse

particulate. Gong and Beaglehole (2000) found that Al, Ca and S present in the diesel particulate samples in 100% of the time. It is well known that diesel fuel contains S. Element S found in petrol samples might arise from lubrication oil (Gong & Beaglehole 2000). Six samples from Parit Buntar indicated the presence of S in the particulate matter. Studies of particulate matter emitted from all type of vehicles exhaust demonstrated the presence of S. This clearly shows vehicles are the main source of S that later contribute to element S in particulate matter samples collected in Parit Buntar.

Besides, as an abundant element is earth crust mineral, Fe also can be present into the atmosphere resulted of iron released into the atmosphere during high-temperature processes such as metal smelting industries (Moreno et al. 2004). They are generally rounded and probably came from the combustion of fossil fuels. There are some that are not rounded are derived mainly from other industrial activities (Esbert et al. 2000).

Samples collected in Komplek Sekolah showed the presences of Cl. Main source of chloride are sea spray even at location hundreds of kilometres from the coast (Harrison et al. 2000). It is possible that these chlorides rich particles were blown from the sea to this area. From Figure 3, we can notice that Parit Buntar is located along the costal line. Hence, the possibility for the chloride to be transport to the locations is very high.

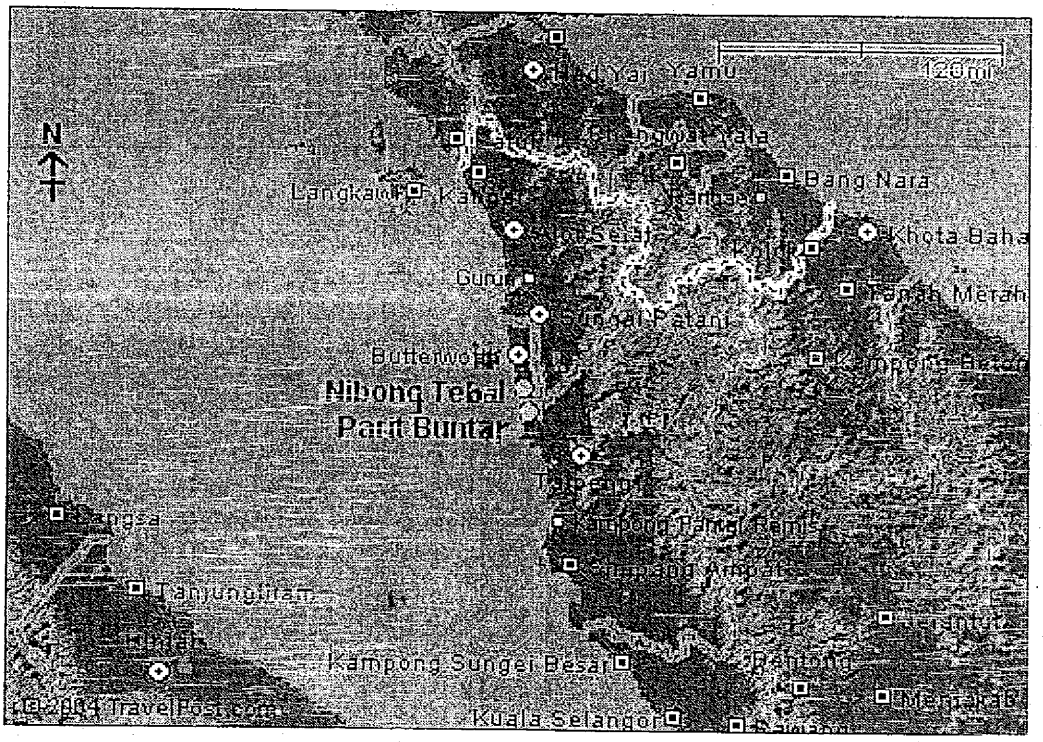


Figure 3. Nibong Tebal and Parit Buntar located along the costal line

Particulate matter containing Cl is emitted from the industrial stacks in Parit Buntar and neighbouring Nibong Tebal dispersed by wind to Parit Buntar and its vicinity. Analysis of particulate matter samples collected from the palm oil mill also shows the occurrence of Cl element. There is a possibility that this particulate matter also being emitted to the Parit Buntar's atmosphere and the wind blow disperse the particulate matter to adjacent location.

Vehicles on road also produce particulate matter containing Cl element. Those species that presence in the particles also has close relationship with the chemical components of palm oil ash. It is believed that particulates also being emitted by the stack of palm oil mill located in the area. Most species found in the particulates can be found in the palm oil fibre ash and shell ash. Major components of fibre ash from boiler are SiO_2, K_2O, CaO, Al_2O_3, Fe_2O_3, MgO, P_2O_5, and SO_3 while major component of shell ash are SiO_2, K_2O, CaO, Al_2O_3, Fe_2O_3, MgO and P_2O_5.

55 spots of the particulate matter analyzed by EDX analyses showed the presence of carbon. It is believe that elemental carbon and/or organic carbon come from biological particles (spores and pollens) as well as those particles produced by the internal combustion of oil and petrol in vehicles. Such combustion produces organic compounds that condense in the air to form spherules smaller than 100nm in diameter, this subsequently aggregate to form larger particles. Because of their small size and low density, these agglomerates can travel in air for long distances (Moreno et al. 2004). All sample collected from six type of vehicles contain C element. This result support that C element is mainly contribution of vehicles regardless what the type is.

Sample from Pekan Baru and Sempadan Perak-Pulau Pinang contain Ti element. Ti is listed in ten most abundant elements in earth crust with 0.565% by weight. Sample from vehicles exhaust and palm oil mill are not showing any presence of Ti element. Hence, Ti might be come from the earth crust material or other sources such as brake dust produced by vehicle's brake system and also from the tyre dust (Adachi & Tainosho 2004).

From the list of particle's size in Table 3, it shows that the particles are ranged from 7.9μm to 158μm. Particles in this range of size is grouped as a coarse paricles. Through the SEM images, shapes of those particulate collected can be divided into 2 group, circular and rod shape.

CONCLUSION

Chemical species components of particulate matters were measure near major roads, parks and background location in Parit Buntar and Nibong Tebal. The greatest contribution to total particulate matters are carbon (organic carbon or/and elemental carbon), Al, Si and O. K and Fe are two species that also frequently presence in the particles composition. Other species such as Ca, Cl, Cu, Mg, Na, Si, S, Ti, Zr, P and N are present randomly.

Particulate matter in Parit Buntar and Nibong Tebal can be categorized as coarse particles because of the size range. The sizes of the particles are from 7.9μm to 158μm. Particles sampled from Nibong Tebal and Parit Buntar can be group into two major different shape, rod shape and circular shape.

Crustal mineral had been identified as the main contributor to the most of the particulate matters in Parit Buntar and Nibong Tebal. Crustal materials are believed to be present due to wind blow on loose soil surfaces especially at a construction site. However, wind turbulence cause by moving vehicles also resuspended the road pavement dusts which contain crust mineral. Vehicles also emit particulate matter to the atmosphere. Analysis of particulate matter from vehicles exhausts show some similarities on the chemical species presence in particulate matter sampled from Nibong Tebal and Parit Buntar. Factories also contribute particulate matter into the ambient air of Parit Buntar and Nibong Tebal. Particulate matters is emitted trough the stacks of the factories.

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AIR QUALITY AND AIR POLLUTION SOURCES IN KERMANSHAH, IRAN

Mehrabi, H. [1] *Zinatizadeh, A.A.L.* [2], *Nor Azam Ramli*[1], *Yavari, F.* [3]
[1] *School of Civil Engineering,*
[2] *School of Chemical Engineering,*
Engineering Campus, Universiti Sains Malaysia,
14300 Nibong Tebal, Penang, Malaysia.
[3] *Department of Environment Protection of Kermanshah,*
Bentelhoda street, Kermanshah Iran.

ABSTRACT

Industrial, urban and traffic pollution have been growing from a few years in most Iranian areas. This city and its surrounding are inhabited by more than one million people. Due to old town planning of the city center, traffic pollution will be the major problem in the urban air pollution in the near future. In order to monitor the air quality over Kermanshah, Grid method was applied. Urban air quality was quarterly measured at 52 points of the city. The urban emission data were presented in typical Grid system. With regard to traffic volume which has been obtained in Kermanshah and also traffic capacity in the city, volume/capacity (V/C), was determined for high traffic regions. The results indicated that 7 streets had high V to C ratio. Results from air quality monitoring in all grid cells showed Dust concentration relative to standard level (9.3 to 167 μg/m^3) in some part of the city is higher which can be due to housing, temporary construction activities lack of asphalt lanes, heavy transportation due to high traffic density and also transformation of Dust from other areas. CO concentration in some grids was higher than standard level and might be resulted from high stopping time and average age of vehicles. The use of fuel oil and gas oil with high sulphur in bakeries, public bathrooms, refinery and domestic heating as fuel was the main factor of high SO_2 level.

Keywords: Ambient Air Quality, Air Pollution Sources, Grid System, Air Pollutant Parameters, Ambient Air Monitoring Stationary Station.

INTRODUCTION

The increase of urbanization in the city will increase energy consumption, which will increase air pollution relating to stationary emissions in the future (JICA 1995). The population of megalopolis cities, motor vehicles, motor fuel consumption, and air pollution all has increased (Walsh 1993). Urban transport is an increasing problem, which has been treated in a series of reports from The World Bank (Walsh 1996, Walsh & Shah 1997). Air quality crisis in cities is mainly due to vehicular emissions. Transportation systems are increasing everywhere and the improvements in technology are insufficient to counteract

growth (Mrinal et al. 2004). Due to constricted road space (only 6%) and unplanned traffic, normal vehicular movements become restricted, which increases the fuel consumption as well as increasing exhaust emission. Low income areas are often an important source of air pollution because of the use of biomass for cooking and heating and informal burning of refuse (The World Bank 2002). Air quality monitoring involves measuring ambient concentrations of pollutants in air in a spatial and temporal context. A simple and reliable method of carrying out a random spatial selection consists in arranging the measurement locations in a square grid with 1 × 1 km extension (Baumbach 1997).

MATERIALS AND METHODS

This study was conducted to identify the air pollution sources in Kermanshah city, in 2003. Kermanshah is located in at 450 km far away from Tehran (capital of Iran) in the west of Iran. It had about 9568.6 (hecs) area, more than 1 million populations and in an altitude of 1322 meters above sea level. It rains most in winter and is moderately warm in summer. Mean value of rainfall was 450.8 mm, annually. Annual average wind velocity was about 4 m/s with most effective direction of west-north-west and east-south-east.

In order to cover the city area a typical Grid system was determined. Each grid size was 1km × 1km. The 1 km^2 surface value is the mean value of the measurements taken at the grid points. Thus, the mean pollution distribution of Kermanshah is obtained and has been seen which areas of the city are in particular needs of clean air measures. The sampling from each grid was conducted whole of 2003, three times in a day (at 8:00 am, 12:00 am and 4:00 pm), one week in a month. Dust, CO and SO_2 were measured as main urban air pollutants. Annual averages of values at each time were calculated. The concentration values were integrated or arranged over the measurement period. Figures 1, 2 and 3 show local distribution of air pollutants (Dust, CO and SO_2) in Kermanshah demonstrated by the grid system.

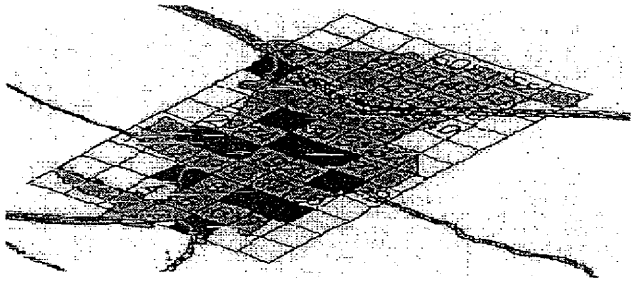


Figure1. Local distribution of dust shows grids with high dust values

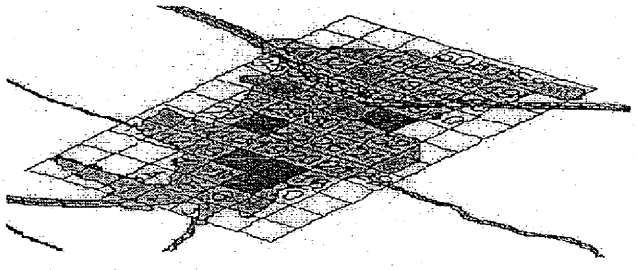


Figure 2. Local distribution of CO shows grids with high CO values

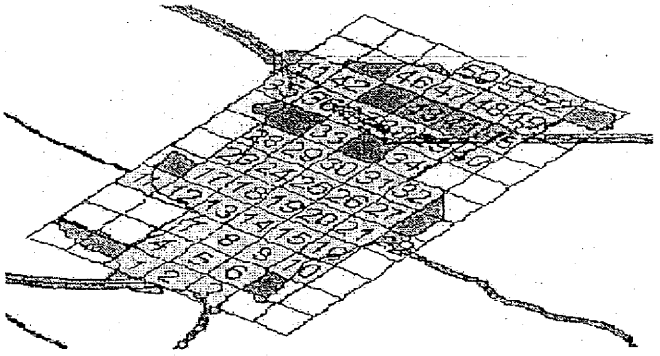


Figure 3. Local distribution of SO_2 shows grids with high SO_2 values

RESULTS AND DISCUSSION

There are two major pollutant sources which affect the air quality of Kermanshah; mobile sources and stationary sources. According to mobile sources two factors are considered; type of vehicles and traffic network. Approximately 9823 public vehicles ply the city streets. The mode of public transportation system in Kermanshah comprises buses, taxies and calling taxis. Most of the buses are old, and the exhaust emission level is much higher than permissible limit. Average age of vehicles under taxi organization was 8.5 years old. Results indicate vehicle's age in Kermanshah was high due to poor economic of the people, low salary and high vehicle prices. Based on accomplished studies about traffic control planning system in Kermanshah, the city has been sectioned to 71 zones with 227 junctions and 204 streets. The results indicated that 7 streets had high volume to capacity ratio. Table 1 shows traffic evaluation of the critical streets. Another parameter which affects on evaluation of the traffic network is wasted time of vehicle in the period of time. Information has been summarized in Table 2.

Table 1. Traffic evaluation of the critical streets (High V/C)

Entering Volume		Exiting Volume		Total Vehicles		V/C	Traffic Volume
Automobile	Bus	Automobile	Bus	Automobile	Bus		
1990	175	404	5	2394	180	0.79	1082
2089	196	962	89	3051	285	1.67	1142
1536	123	2752	368	4288	491	0.97	780
2399	404	-	497	2399	901	1.4	1404
2955	660	3102	720	6057	1380	1.2	1274
2348	39	1109	80	3457	119	1.19	716
1295	4	3634	10	4929	14	0.76	911

Table 2. Wasted time and distance at peak hours

	Wasted time and distence at peak hours	
Total Vehicles	(minute)	34336
Total Vehicles	(km)	203750
Average Fuel Consumption	(lit)	30559

Inside the city sources include a refinery, bakeries, domestic and commercial units. All measured parameters (CO, NO, NO_x and SO_2) from the refinery stacks indicated that emissions were lower than standard levels.

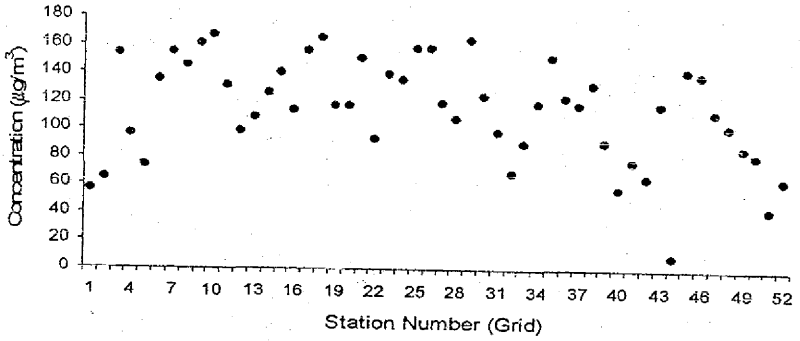


Figure 4. Annual average concentration of Dust in each Grid

Figure 4 represents annual average concentration of Dust at 52 mobile stations measured by grid method in 2003. Dust concentration ranged between 9.3 $\mu g/m^3$ (at grid number 44) and 167 $\mu g/m^3$ (at grid number 10) in 2003. Yearly average concentration of Dust at 3, 7, 9, 10, 17, 18, 21, 25, 26, 29 and 35 grids were higher than air quality standard. Most of the areas where have high concentration of Dust are new towns around the city center which its reasons can be due to housing, temporary construction activities and lack of asphalted lanes. High Dust level at grids number 9 and 25 (traffic zone; 118-119) might be originated from heavy transportation due to high traffic density and also transformation of Dust from other areas.

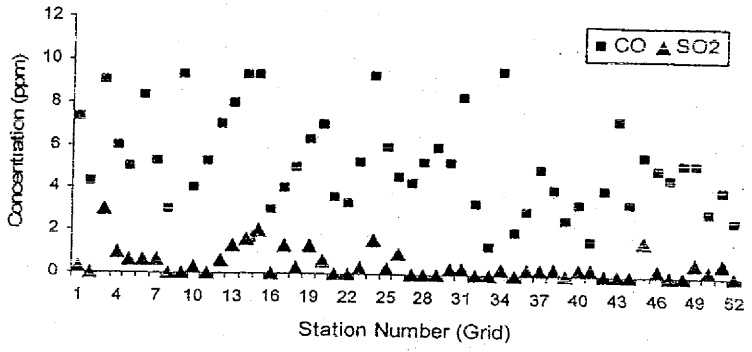


Figure 5. Annual average concentration of CO and SO_2 in each grid

CO concentration (Figure 5) ranged between 1.3 ppm (at grid number 33) and 9.6 ppm (at grid number 34). Average concentrations of CO at 9, 14, 15, 24 and 34 grids were higher than air quality standard. The maximum level of CO concentration was observed at grid number 34 which might be due to high traffic density in this area (Beheshti Boulvard, traffic zone; 147-152), and also because of the high truck passage from/to oil refinery. Since the grid cells of 9, 14 and 24 have been identified as regions with high density of traffic, so, high CO concentration at these grids might have resulted from high stopping time of vehicles. Other parameter as mentioned is high average age of vehicles in Kermanshah.

Figure 5 shows local distribution of SO_2 at 52 grids. SO_2 value in most of the grids was higher than air quality standards. SO_2 concentration ranged between 0 ppm and 3 ppm. The maximum SO_2 value was 3 ppm at grid number 3. The use of fuel oil and gas oil with high sulphur in bakeries, refinery and domestic heating were the main factor of high SO_2 level in the city.

CONCLUSION

The main objective of this paper is to identify the air pollutant sources in the Kermanshah. Air pollution potential at all sources were evaluated by monitoring and measuring the most polluted parameters (Dust, CO, SO_2). Finding of this study showed that these parameters in most part of the city were lower than standard level. In some part of the city air pollutants concentrations have been higher than air quality standard. It is resulted from activities which are being carried out in industrial regions and inside the city sources. Air quality needs to be monitored continuously by installing ambient air quality monitoring stationary station as it can not be judge that air pollution in a city is high unless enough data is collected. The results according to traffic volume indicated that 7 streets had high volume/capacity ratio (Mosavari Street, Shariati Street, Siloo Street, Modarres Street, Beheshti Street, Afshar Toos Street, and Khordad-15 Street). Average age of vehicles in Kermanshah was high due to poor economic of the people, low salary and high vehicle prices. The maximum and minimum annual Dust values at 52 grids were 167 $\mu g/m^3$ (at grid number 10) and 9.3 $\mu g/m^3$ (at grid number 44), respectively. Most of the regions where had high concentration of Dust are new towns around the city center which its reasons can be due to housing, temporary construction activities and lack of asphalted lanes, and also heavy transportation in some part of the city. The maximum annual average concentration of CO at 52 grids was 9.6 ppm that might be due to high density of traffic in some parts of the city and can be resulted from high stopping time of vehicles. The use of fuel oil and gas oil with high sulphur in bakeries, refinery and domestic heating as fuel were the main factor of high SO_2 level.

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FITTING TWO PARAMETERS WEIBULL DISTRIBUTION FUNCTION FOR PARTICULATE MATTER IN PENANG

Noor Faizah Fitri, Nor Azam Ramli & Ahmad Shukri Yahaya
School of Civil Engineering,
USM Engineering Campus,
14300 Nibong Tebal,
Pulau Pinang.

ABSTRACT

Air pollution is one of the most important issues that have been discussed extensively all over the world. In Malaysia, air pollutant emissions were monitored all over the country to detect any significant changes which may cause harm to human health and the environment. This research focused on particulate matter as it is known can cause severe health impact to human as well as environment. However, a well developed system need to be used in order to analyze PM_{10} emission inventories. In this paper, two parameters Weibull distribution model were developed and verified to simulate the trend of PM_{10} emission monitoring data in Seberang Perai. This study offer air quality prediction tools using Maximum Likelihood Estimators and Weibull probability plot. The Weibull distribution function plots were established.

Keywords: Weibull probability plot, Maximum Likelihood Estimators.

INTRODUCTION

PM_{10} is referred as coarse fraction that includes all suspended particles in the size range of above 2.5μm (microns) in aerodynamics diameter. The coarse fraction has been judged to be made up mostly of natural and organic particles (Powe & Willis 2003). PM_{10} are emitted from motor vehicle exhausts, heat and power generation plants, industrial processes and open burning activities (Department of Environment Malaysia 2002).

The length of time the particles remain in the atmosphere and their diffusion in it depend on their size and density, and also on the prevailing wind speed and how high the dusts are whirled up in the atmosphere. Coarser particles settle within hours or days. However, they can also drift over hundreds of kilometres if they are carried out high enough (Fellenberg 2000). Therefore, researches on PM_{10} are vital in order to determine their emission source reduction as it is well known as the cause of bad health effects.

In this research, Weibull distribution has been chosen to fit the PM_{10} data. The Weibull distribution function provides a close approximation to the probability laws of many natural phenomena (Kottegoda & Rosso 1997). The Weibull distribution function contains two parameters, α and β. The scale parameter β, reflects the size of the units in which the random variable y is measured. The parameter α is the shape parameter. By changing the

value of the shape parameter, a widely varying set of curves can be generated to model real-life failure time distribution (Mendenhall & Sincich 1994).

This study have been carried out with two main objectives that are to fit the most appropriate distribution to the PM_{10} data and the second objective is to predict the exceedences and return period of a critical concentration by using cumulative distribution function.

METHODOLOGY

Weibull distribution has been used to model one year hourly data of PM_{10} emission in Seberang Prai for the year 1998. The two parameter Weibull probability density function with parameters α and β is given by:

$$f(x)=\frac{\alpha}{\beta}\left(\frac{x}{\beta}\right)^{\alpha-1}\exp\left[-\left(\frac{x}{\beta}\right)^{\alpha}\right], x>0, \alpha>0, \beta>0 \quad (1)$$

The cumulative distribution function takes the form:

$$Fx(x)=1-\exp\left[-\left(\frac{x}{\beta}\right)^{\alpha}\right], x>0, \alpha>0, \beta>0 \quad (2)$$

In order to estimate the α and β values for Weibull distribution, two methods have been applied, that is:

- Weibull probability plot
- Method of maximum likelihood estimators

The Weibull Probability Plot

Probability plot is a visual method for presentation of data in the form of graph. This plot can be used to estimate how well a theoretical distribution fits a sequence of data. The PM10 data is rearranged to n ordered sequences where $x_1 > x_2 > \ldots > x_n$. In order to estimates the α and β values, graphs of y_i vs x_i have been plotted where y_i is the solution of the following equation;

$$y_i=\ln\left[-\ln\left(1-F(t_i)\right)\right] \quad (3)$$

$F(t_i)$ was calculated using:

$$F(t_i)=\frac{(i-0.3)}{(n+0.4)} \quad (4)$$

x_i was then calculated by the following equation:

$$x_i=\ln(t_i) \quad (5)$$

The plot of y_i *vs* x_i was regressed to get α and β values.

The Method of Maximum Likelihood Estimators

Method of maximum likelihood estimators procedure is an alternative to the method of moments. The method of maximum likelihood and exposition of the properties of maximum likelihood estimators are the result of the work by Sir Ronald A. Fisher (1890 – 1962)

(Mendenhall & Sincich 1994). In this method, β was obtained by solving the following equation:

$$\frac{\sum_{i=1}^{n}\left(x_i^{\beta}\ln x_i\right)}{\sum_{i=1}^{n}x_i^{\beta}}-\frac{1}{\beta}-\frac{1}{n}\sum_{i=1}^{n}\ln x_i=0 \qquad (6)$$

α was then calculated using the following equation:

$$\alpha=\left(\frac{1}{n}\sum_{i=1}^{n}x_i^{\hat{\beta}}\right)^{\frac{1}{\beta}} \qquad (7)$$

Goodness-of-fit

Goodness of fit is a method to examine how well a sample of data agrees with a given distribution as its population. From this method, the best distribution that fit the air pollutant data will be chosen. Probability plotting method or known as graphical methods has been applied. Graphical methods form a very useful visual method to verify whether a theoretical distribution fits an empirical distribution.

By using Mathcad software, cumulative distribution function (cdf) plot for every distribution have been plotted against the variates. Cdf versus theoretical data were also plotted. Then, to identify which is the best distribution, every theoretical cdf plot was overlaid with actual data.

RESULTS AND DISCUSSION

Figure 1 shows the compared results of two methods applied for the Weibull distribution and observed data of PM_{10} 1998 concentration at the Seberang Prai station. For PM_{10} (1998), it shows that MLE fits better the observed data compared to Weibull probability plot. MLE starts to overestimate at concentration 130μg/m^3 and Weibull probability plot start to overestimate at lower concentration that is 80μg/m^3.

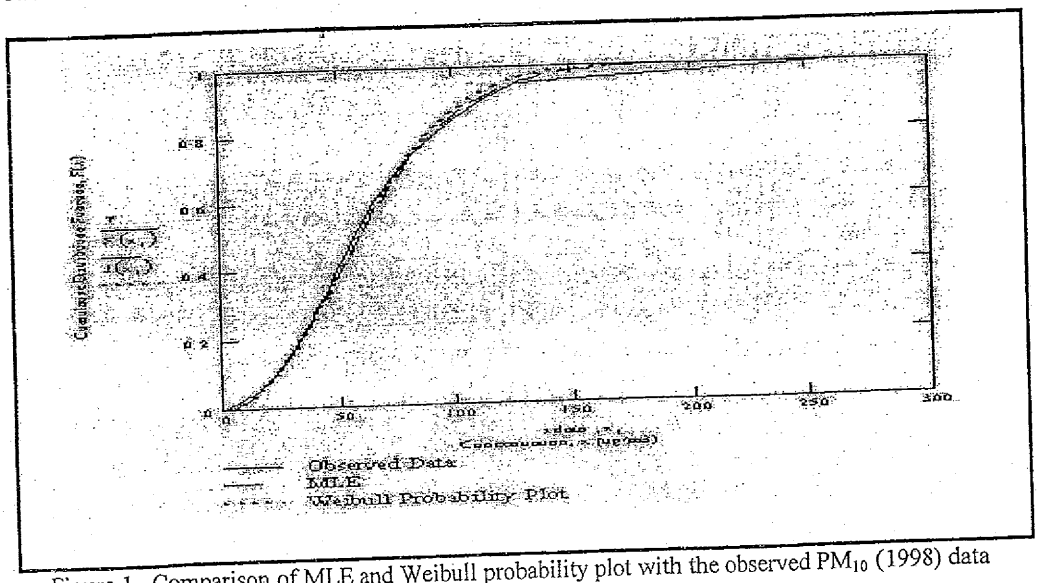


Figure 1. Comparison of MLE and Weibull probability plot with the observed PM_{10} (1998) data

Fitted Result for PM_{10} Data

Figures 2 and 3 show the pdf and cdf plots for PM_{10} in 1998 by using the method of MLE. The values of $\alpha = 1.913$ and $\beta = 70.434$ for PM_{10} in 1998. Pdf plot by using method of MLE for Weibull distribution for PM_{10} in 1998 shows almost similar distribution with very long tail to the right. This pattern indicates that there are dominant sources that contribute to high PM_{10} concentration in Seberang Prai and increasing with time. However, this is not peculiar as it is known and mentioned before that Seberang Prai is a heavily industrialized area and this sector is believed to have become a major contributor to air pollution problem. From Figure 2(b), the probability for PM_{10} (1998) concentration is more than $150\mu g/m^3$ is equal to 0.014 ($F(x>150)= 0.014$) and the return period is 5.11 days for PM_{10} in 1998. Return period is the days of exceedances within one year.

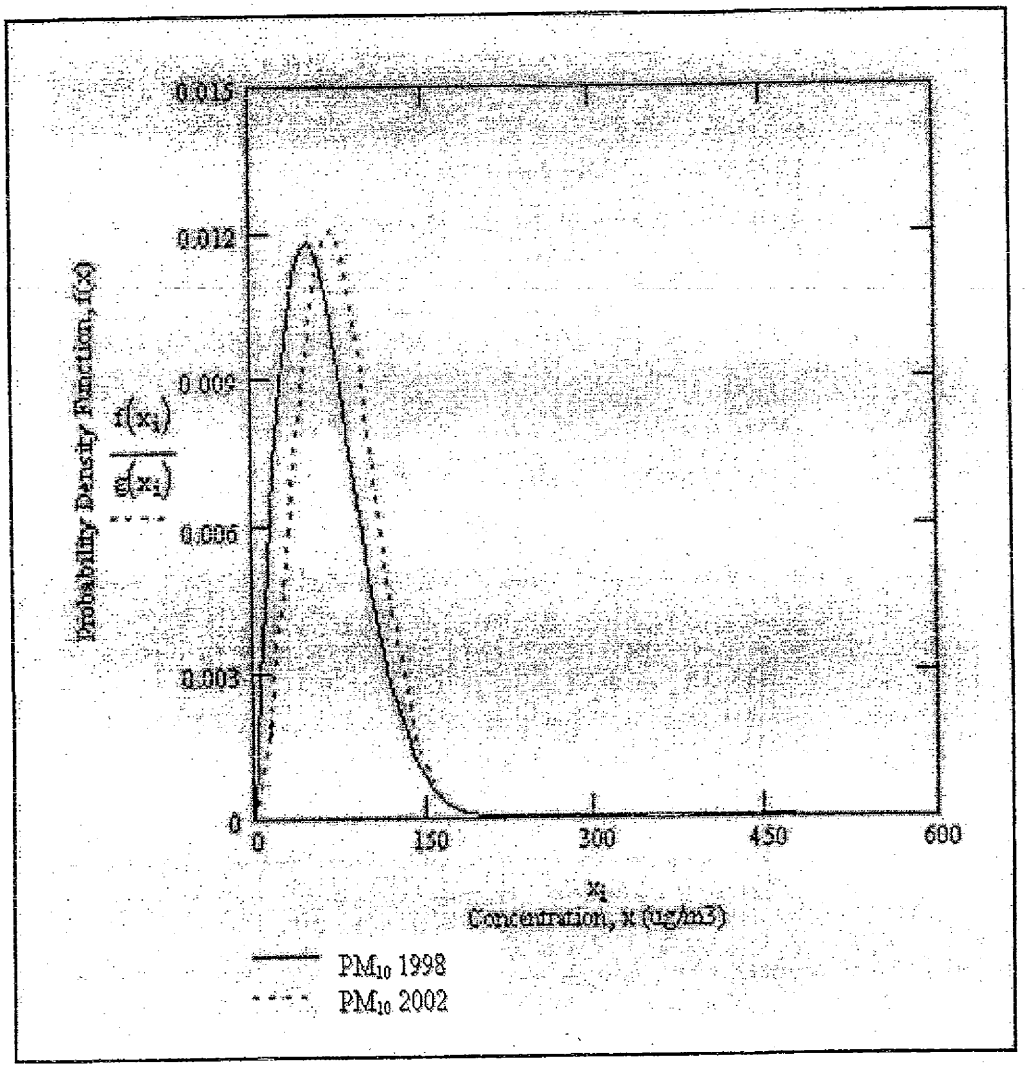


Figure 2. Weibull probability density functions for PM_{10} (1998) and PM_{10} (2002)

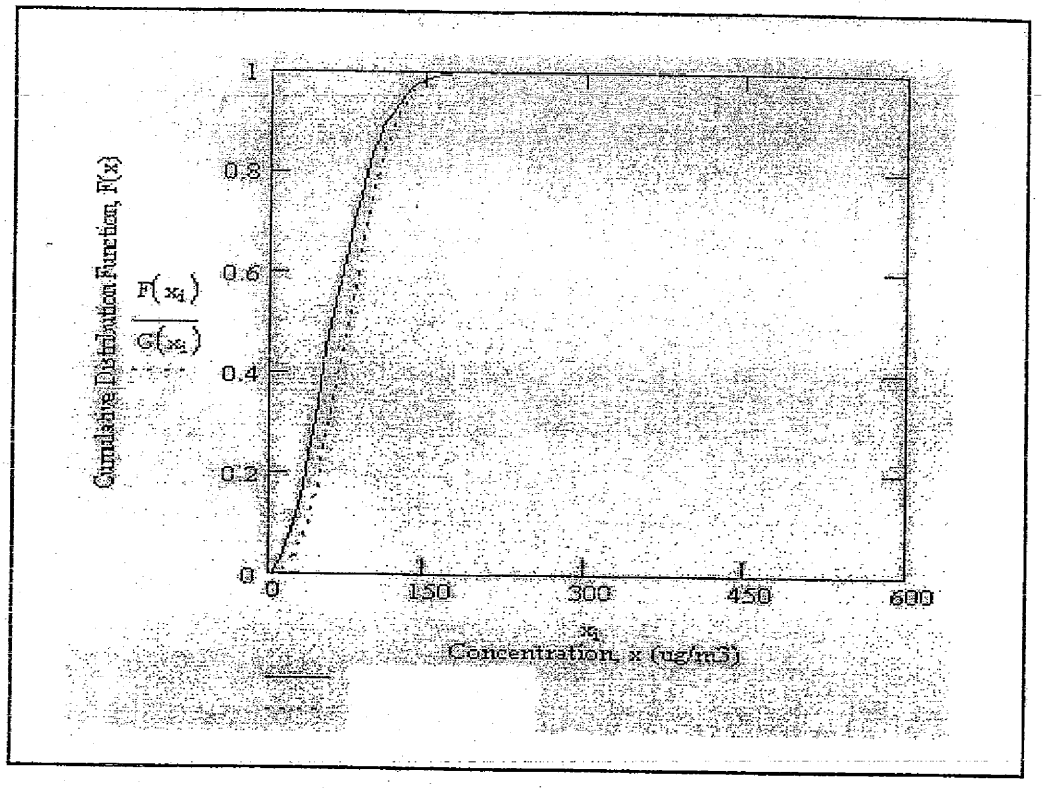


Figure 3. Weibull cumulative distribution functions for PM_{10} (1998) and PM_{10} (2002)

CONCLUSION

In this study, Weibull distribution by using method of MLE and Weibull probability plot have been selected to fit the PM_{10} data. From the two methods applied for the Weibull distribution, it was found that method of MLE could fit the data better than the Weibull probability plot because the method of MLE start to overestimate the observed data at higher concentration compared to Weibull probability plot.

The cdf and pdf plot obtained in this study can be used as a prediction tool. In this study, the probabilities for air pollutants emissions exceeding the Malaysian Ambient Air Quality Guideline have been predicted. The probability for PM_{10} (1998) exceeding the concentration of more than 150μg/m^3 is 0.014 (F(x>150) = 0.014). The return period for PM_{10} (1998) exceeding concentration of more than 150μg/m3 is 5.11 days.

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URBAN AIR QUALITY MONITORING USING GIS AS A MANAGEMENT SYSTEM

Saeid Rezae Nejad & Nor Azam Ramli
School of Civil Engineering,
Universiti Sains Malaysia,
Engineering Campus,
14300 Nibong Tebal, Pulau Pinang.

ABSTRACT

Urban air pollution is one of the primary priorities of environmental concern due to the public health questions. Air pollution is a major environmental concern in Iran. Approximately 4,000-5,000 Tehran residents die annually due to air pollution. Kerman city has been chosen for this case study. The city of Kerman with 550,000 inhabitants is located in the south eastern of Iran with the urban extension of 10.26x7.53. The annual mean wind intensity is 3.1m/s.The predominant wind directions are as follows: NNW 19.77%, ENE 18%, NNE12.8%, N 11.63%, NE 11%.Both, the west and east of the city are surrounded by mountains. Kerman, as many other big cities in Iran, faces expanding urbanization, with economic growth, increase in air pollution, and loss of green or agricultural space. In this study the monitored environmental data from downtown urban monitoring station in 2004-05 were collected and meteorological data have simultaneously been collected. Kerman digital map at scale of 1:25000 was being loaded and ArcView GIS software 3.1 has been used on the Geographic Information System (GIS) desktop. The comparison of mean values of pollutant concentration between two seasons in Kerman city is accompolished by Statistical descriptive analysis. Chief industries contributed in air quality of the city were identified. Kerman cement plant has high impact in the air quality of city.

INTRODUCTION

Air pollution has been with us since the first fire was lit, although different aspects have been important at different times. Air pollution is a universal problem with consequences ranging from damaged buildings, plants to declining crop yields and the deaths of people. The World Health Organization (WHO) estimates that 500000 people die prematurely each year because of exposure to ambient concentrations of airborne particulate matter (Colls 2002). Also, approximately 4,000-5,000 Tehran residents die annually due to air pollution (IRNA 2002). A major factor behind the suffocating air pollution in urban Iranian area is the dramatic rise in the country's energy consumption. From 1980-1998, Iran's total energy consumption ramped up from 1.6 quadrillion Btu (quads) in 1980 to 4.7 quads in 2000 nearly a three- fold increase. Moreover, Iran's energy-related carbon emissions have been on a steady climb for two decades. Since 1980, carbon emissions in Iran have risen by

240%, from 33.1 million metric tons emitted in 1980 to 80.8 million metric tons emitted in 2000 (Energy Information Administration 2002).

The city of Kerman, as many other big cities in Iran, faces expanding urbanization, with economic growth, increase in air pollution, and loss of green space. The city of Kerman is located in a large and flat plain about 1076 kilometers from Tehran, the national capital of Iran. It has been a historical town and it is the provincial capital now. The city has about 550,000 inhabitants is placed at the eastern south in Iran, with longitude between 49.736°(DD) and 51.223°(DD), and latitude between 33.453°(DD) and 33.457°(DD) with an urban extension of 80 square km and 1710 meters at the sea level. The city is located on the flanks of the Loot desert. The region is mostly classified within hot and dry climate in the summer and moderately dry in the winter. The annual rainfall reaches 146mm and the average annual relative humidity is 32%. January is the coolest month with a daily average temperature of 6.2°c while in July the daily average temperature reaches 28.1°c for the warmest month .The maximum hourly average temperature in the city is 40.3°c while the minimum hourly temperature reaches -10.3°c .The annual mean wind speed is 3.1m s^{-1}, whilst the predominant wind directions are: NNW 19.77%, ENE 18%, NNE12.8%, N 11.63%, NE 11%.for the year 2004. The amount of dust and SPM concentration is relatively high in Kerman city. This phenomenon takes place due to natural and anthropogenic resources of SPM in the region.

METHODOLOGY

Arc View GIS version 3.1 is used as the Geographic Information System (GIS) tools for development of the exposure model. Arc View GIS software is applied to query, integrate, analysis, visualize spatial data on computer desktop. It has basic mapping functionality and advanced geographic information system capabilities. The SPSS 12.0.1 has been chosen for the statistical analysis.

Applied data

- The basic digital map of Kerman city at the 1:25 000 scale on the GIS desktop.
- Air pollutants data collected by the air pollutants monitoring station and portable.
- Meteorological data collected by the aeronautical and synoptic stations.

Method

There are three steps in doing this study:-

Step 1- Gathering air pollution data, meteorological data and other relevant data on the case study location.
Step 2- Preparing the digital Map of case study location on the GIS desktop.
Step 3- Data analyzing by means of proper methods and software.

- **Map preparation on the GIS desktop**

Step 1 - Using Arc view GIS software to query, integrate, manipulate, analysis and visualize spatial data such as landuse and contour of case study area on the GIS desktop

Step 2 - Map manipulation and management of case study district by Using Merge as tools in geoprocesssing extension to Arc View. Merge creates a new map by piecing together two or more map.

Step 3 - Thematic maps of industrial area, downtown, air pollution analyzer location and meteorological station location are designed by using layout

❖ **Air pollutant and meteorology data analysis**

The wind rose on the basis of meteorological observations of wind speeds and wind directions of the case study area has been drawn to show the information of the wind speeds distribution, and the frequency of the varying wind directions. The compass is divided into 16 sectors, one for each 22.5 degrees of the horizon. A wind rose gives information on the relative wind speeds in different directions, i.e. each of the two sets of data (frequency and mean wind speed). In addition, long term meteorological data analysis for a period of five years of monthly average meteorological data from 1999 until 2004 is carried out in the city.

Analysis of diurnal, seasonal of CO and dust collected by air pollutant analyzer station is carried out by means of descriptive statistics. The SPSS software version 12.0.1 is used for this purpose. Moreover, main industries associated with air quality in the city are identified. Comparison pattern of air pollution concentrations (mass/m^3) released to the ambient of the city is carried out by means of HYSPLIT model with the air pollution data.

RESULTS AND DISCUSSION

Meteorological Analysis

Pressure patterns over the earth are in constant flux as air pressure rises in some regions and falls in others. These relatively high-pressure systems showed in Table 1 are related to the majority clear sky, light winds, and atmospheric stability in the region. The monthly average temperatures over five-year period are recorded at the weather station in Table 1. The pre-selected ''comfortable'' temperature is usually 18°C. The Table 1 expresses the average temperature of six months during the year falls below this standard temperature. Hence, the requirement of heating space and burning of fossil fuel is enhanced much air pollution potential during this period of year. The strong night cooling and day heating are specific characteristic in the region. This phenomenon produces an important variation in mixing heights and inversion layers.

Table1. Summary of 5 years of monthly average meteorological data, measured by the Meteorology Organization of Kerman from 1999 until 2004

	Month											
Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pressure (Hpa)	827	824	826	824	824	822	820	821	824	828	828	828
Temperature (°c)	6.2	6.4	11.3	16	21.4	25.3	28.1	25.3	23.8	18.3	13	8
Rel.Humidity %	50	48	36	33	24	19	20	22	20	27	37	47
Wind speed (m/s)	1.8	2.8	3.8	4	3.8	3.5	3.8	3.6	3.1	2.6	2.3	1.8
Precipitation (mm)	22.6	20	9.2	12.4	4.8	0.3	0.1	0.7	0.5	0.3	5.8	20.2
Heliophany (hrs)	6.8	7.9	8.2	8.5	10.2	10.8	11.2	11.5	11	9.5	8.6	7.5

The area presents low relative humidity 22% and 40% during summer and winter respectively. This could be resulted much solar radiation received and reflected by the earth

in the area. The higher solar radiation consequently would increase much generation of oxidants in daytime. The annual mean rainfall according to table1 for the five-year period is less than 100mm, which occurs especially during the winter months (November to April). The precipitation serves as a cleansing agent for the atmosphere removing particulates and soluble gases in a process called ''washout''(Peavy 1985). Less precipitation in the city is derived by the specific location of the region in an arid to semiarid zone of low rainfall. The annual mean wind intensity is 3.1m/s due to the analysis wind intensity mean value for five years in the city (Table 1). The annual mean daily heliophany is 9.3h. Therefore, the relatively high solar radiation is derived in the area. This event enhanced much production of oxidant in the city.

The effect of wind direction is to find out the direction of transport of released pollutants. Table 2 and Figure1 indicate that the predominate wind in the city blows from NNW, N, NNE, NE, and ENE. Consequently, this pattern would cause pollution to move toward SE, SSE, S, SSW, and SW from each source throughout the city. On the mesoscale and microscale, topographical features significantly influence wind flow. The contour in the Figure 2 prepared in the GIS desktop indicates the existence of natural barrier in the west. This topographic condition causes the wind direction pattern in the city as shows in the Figure1.

Table 2. Maximum wind direction in Kerman 2004

Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Percent	11.6	12.8	11	18	3.5	1.7	1.7	1.7	1.7	2.5	1.2	3	5.3	2.4	3.5	19.8

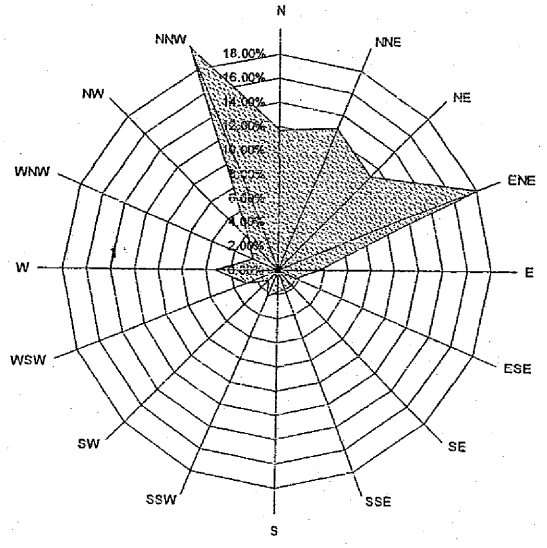


Figure1. Maximum wind direction in Kerman 2004

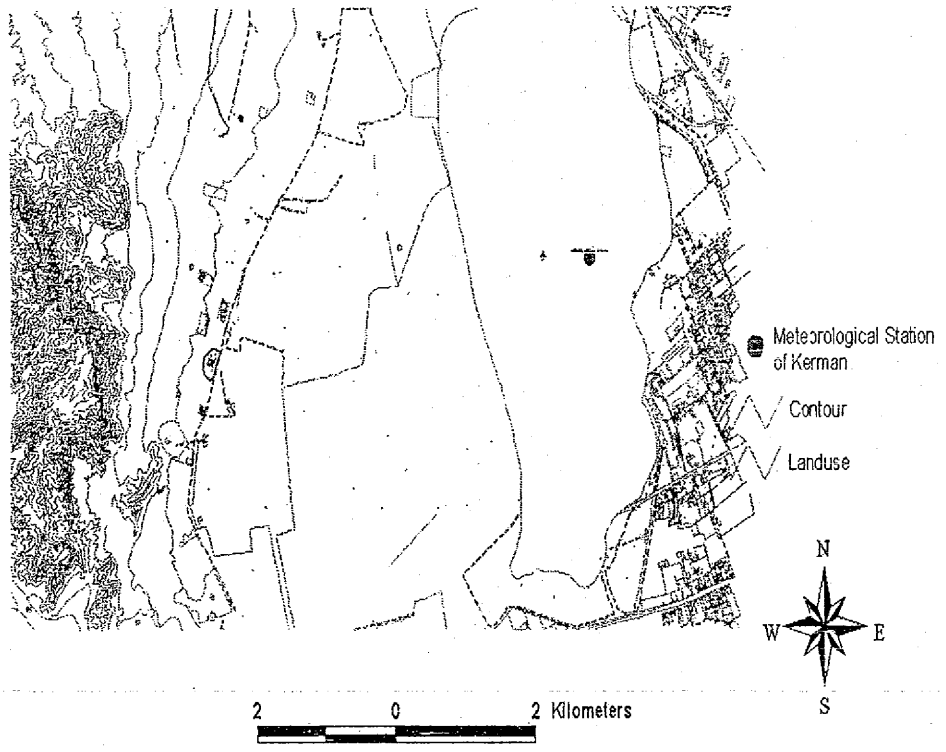


Figure 2. Land use, contour and meteorological station of Kerman

Pollution releases from different sources in the city are continuous that the pollutants are diluted right at the point of release. The resulting pollutants concentration is inversely proportional to the wind speed; double the wind speed and the concentration. In the ambient becomes half of that with the lighter wind.

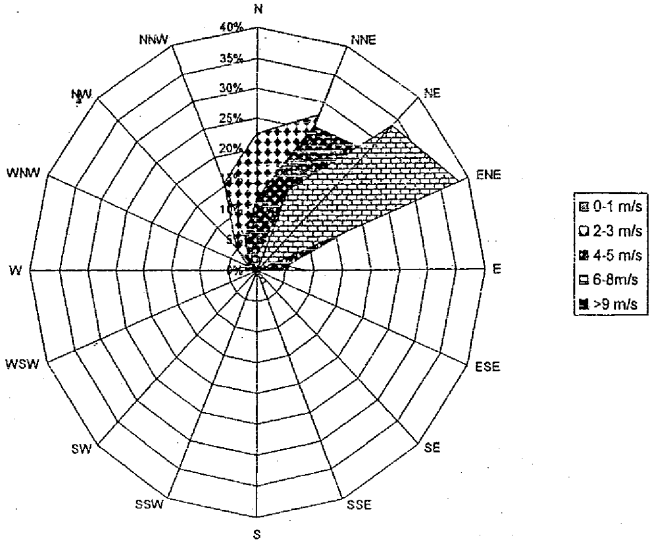


Figure 3. Wind rose 2004 Kerman

Figure 3 shows the frequency of mean speed and direction in 2004 Kerman .The wind rose in Figure 3 indicates that the greatest percentage of winds direction was from the NE and ENE that speeds of 6-8 m/s were recorded for winds from that direction. The wind rose shows that about 60 percent of days have wind speed, more than 4m/s.

Air Pollutants Analysis

The evaluation of carbon oxide concentration among three runs of eight- hour periods indicates that the highest mean value is between 4 pm to 12 pm (Table 3 and Figure 4). Since the basic source of CO is automobile emission, this evening peak takes place because of the traffic jam caused by the rush hour period, especially in downtown area (Figure 5).

Table 3. Carbon oxide concentration (ppm) 8 hours period, Kerman from July 2004 until February 2005

Period	Sample number	Minimum	Maximum	Mean	Std. deviation	Variance
00-08	223	00.0	5.01	1.67	0.84	0.71
08-16	223	0.18	5.39	2.37	0.87	0.76
16-00	223	00.0	9.77	3.17	1.7	2.9

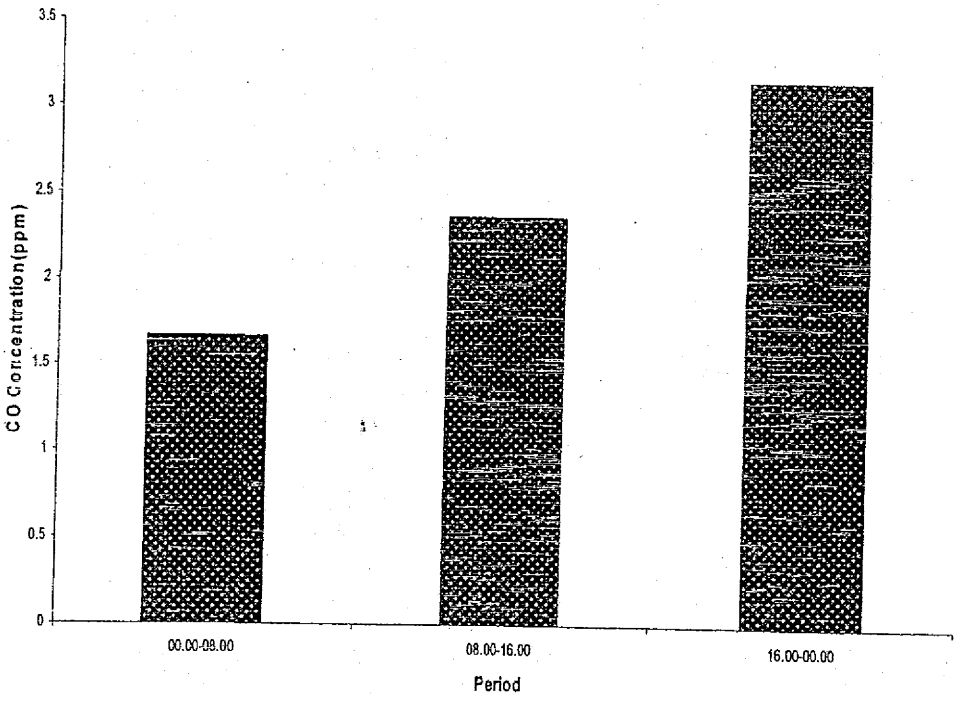


Figure 4. Carbon oxide concentration (ppm) 8 hours period, Kerman from July 2004 until February 2005

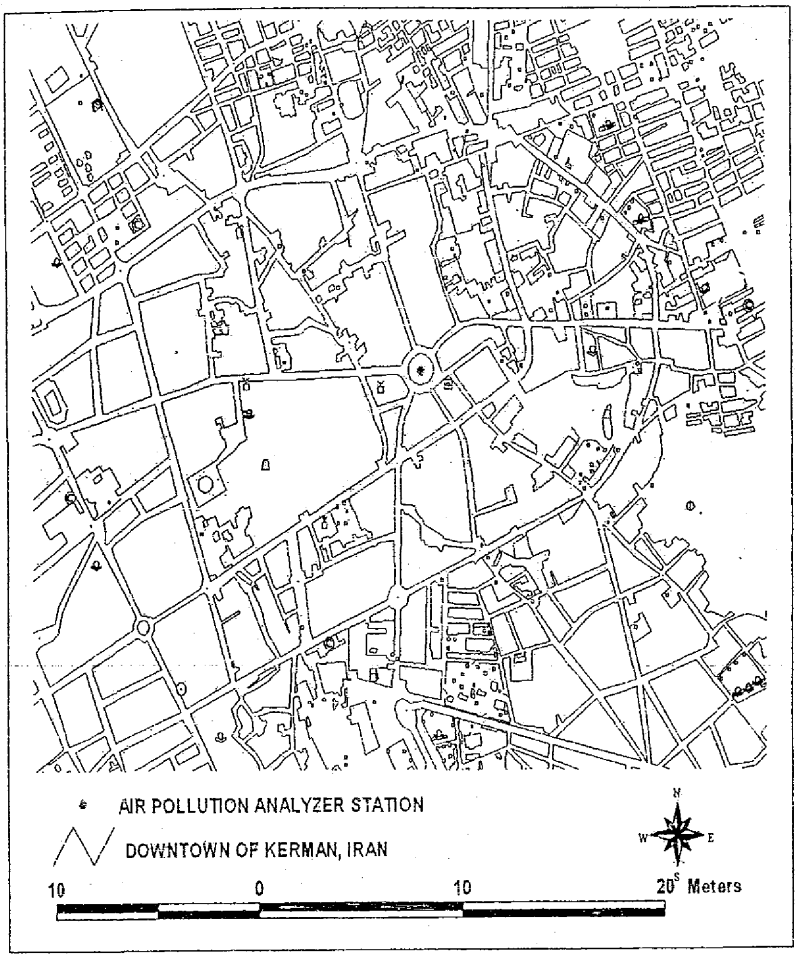


Figure 5. Air pollution monitoring station in downtown of Kerman

Table 4 shows higher dust mean value in winter compared to summer. This phenomenon is probably attributed to decline of green space during winter, especially in the city green belt. It allowed much penetration of dust to the city from desert in the winter.

Table 4. Dust concentration ($\mu g/m^3$) Kerman 2004

Season	Sample number	Minimum	Maximum	Mean	Std. Deviation	Variance
Summer	81	54.00	237.90	93.59	29.38	863.23
Winter	143	24.95	294.4	101.21	38.05	1448.20

Industrial Sources Relevant to the City Air Quality

The main industrial sources have been contributed in the air pollution in the city are located (a) old cement plant (Kerman Cement Co.) with capacity of 3600 tons/day (Kerman Cement, 2005) in the West edge of city, because of improper location and adjacent to the residential area have significant effect in the air quality of the city (Figure 6). In addition, asbestos-cement factory (Kermanite Co.) next to the Kerman cement plant which produces asbestos-cement, corrugated and plane sheets, Sewers and high pressure water conduits enhances the problems in the air quality of the city. (b) a rubber plant in the South of the city due to distance and location in downwind has less significant impact on the air resource, (c) The agro and food production e.g. dairy plant located in the Eastern south site, but with less impact on the air quality in the city.

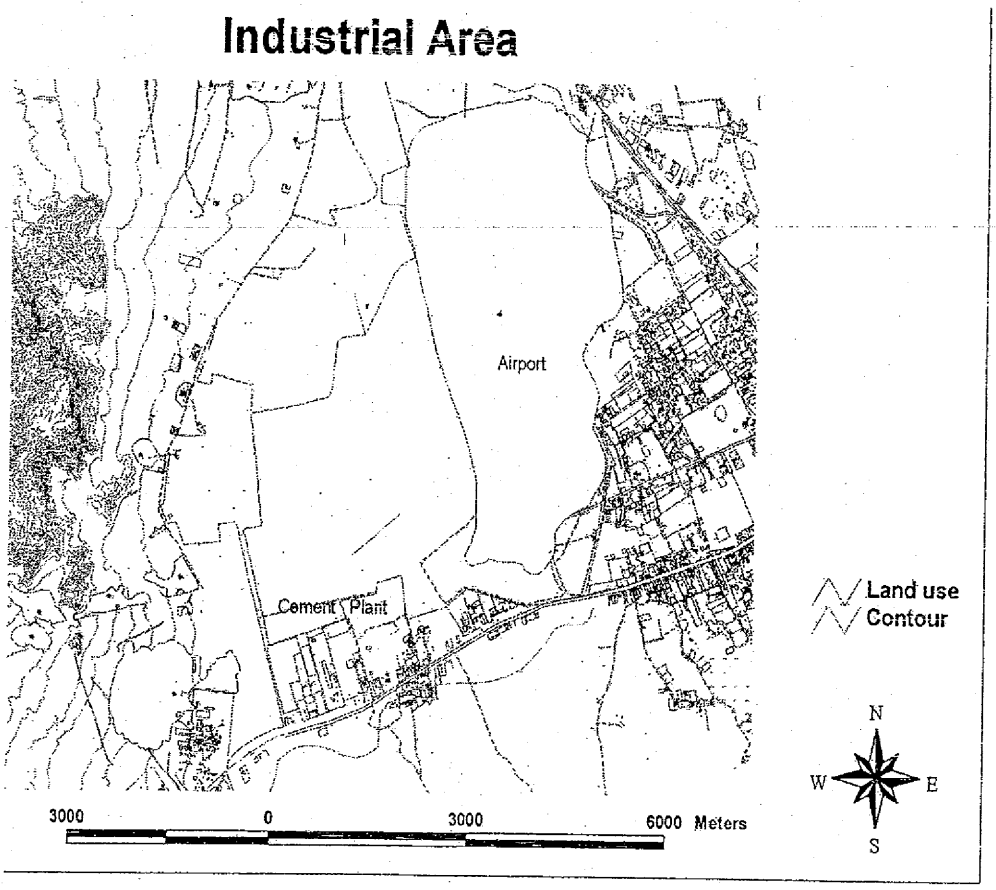


Figure 6. Landuse, industrial area and cement factory

CONCLUSION

In the current research, study of the contour and landuse of Kerman city on the desktop of GIS revealed that it is located in a flat area. It was profoundly placed at edge of dessert surrounded by the mountains in the Eastern North, East and West. Consequently it makes a great complexity of weather in the different location of the city area. Analysis of wind

direction and wind speed was carried out by plotting wind rose. The predominant wind directions in the city were as follows: NNW 19.8%, ENE 18%, NNE12.8%, N11.6%and NE11%. The peak of carbon monoxide in eight –hour period studied in the air pollution station located in downtown was observed in the evening with value of 3.2 (ppm). Higher dust concentration mean value in winter compare to summer is due decline of green space in winter and increase of dust penetration from desert in the city. Furthermore, the old cement factory has immense impact in the air quality of city due to inappropriate location.

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AIR QUALITY PREDICTIONS USING LOG NORMAL DISTRIBUTION FUNCTIONS OF PARTICULATE MATTER IN KUALA LUMPUR

Jannatul Naemah Mohamed Sedek , Nor Azam Ramli & Ahmad Shukri Yahaya
School of Civil Engineering,
USM Engineering Campus,
14300 Nibong Tebal,
Pulau Pinang.

ABSTRACT

Kuala Lumpur, Malaysia has been developed from a small settlement at the confluence of the Klang and Gombak rivers into a vibrant and bustling metropolis city. The associated rapid economic growths have started to impose costs in terms of industrial pollution and the degradation of urban environment. Among them, air pollution is the major issue that has been affecting human health, agricultural crops, forest species, and ecosystems. The aim of this research work was to develop a tool needed to analyze the statistical character of air quality data in Kuala Lumpur, Malaysia. One theoretical distribution, Log normal was used to fit parent distribution of PM_{10} for 1998 and 2002. Two parametric estimating methods, method of maximum likelihood and method of moments, were used to estimate the parameters of the theoretic distributions. From the statistical properties of air pollutants, the exceedence frequency of air pollutant concentration can be predicted. The results of this work provide useful information for air quality management and can also be used to develop the corresponding air pollution control strategy.

INTRODUCTION

Air pollution is defined as the presence in the outdoor atmosphere of one or more pollutants in such quantities and of such duration as may tend to be injurious to human, plant, or animal life, or to property, or which may unreasonably interfere with the comfortable enjoyment of life or property, or the conduct of business (Canter 1996). Among different environmental pollution problems, air pollution is reported to cause the greatest damage to health and loss of welfare from environmental causes in Asian countries (Hughes 1997). Although data and study on air pollution in Malaysia are very limited, one review that had been done by Afroz et al. (2003) indicated that suspended particulate matter (SPM) and nitrogen dioxide (NO_2) are among the predominant pollutants.

The impact of air pollution is broad, especially for human being where it can cause several significant effects (including carcinogenic effects). State-of-the-art epidemiological research has found strong links between air pollution and morbidity and mortality rates, with air pollution potentiating a wide range of human cardio respiratory health problems especially in children, old, and ill people. Such health problems include cardiac arrhythmias, reducing lung function, asthma, chronic bronchitis, and increasing respiratory symptoms, such as sinusitis, sore throat, dry and wet cough, and hay fever (World Health Organization 1998).

There are several form of distributions used to fit the parent distribution of air pollutant concentration data. In fact, several frequency distribution functions have been proposed in literature and used to fit air quality measurements. These distributions are log normal distribution (Mage & Ott 1984) weibull distribution (Georgopoulos & Seinfeld 1982) and type V Pearson distribution (Morel et al. 1999).

The lognormal distribution was more widely used to represent the type of air pollutant concentration distribution. This distribution was not only used for ambient air quality data but also for indoor air quality and dissolved solids in groundwater (Ott 1990). From the study that has been done by Hadley and Toumi (2003), the two parameter log normal distribution can be a very good description of annual mean daily sulphur dioxide concentrations for a wide range of ambient levels, time periods and monitoring site types. The log normal distribution has a consistently better fit to the data than the normal distribution.

There are many techniques to estimate the distribution parameters, namely the method of moments, percentiles and maximum likelihood estimation (MLE) (Georgopoulos & Seinfeld 1982). The method of moments was more widely used whereas the method of maximum likelihood provides the best estimate of the parameters (Mage & Ott 1984).

DATA

In this paper, the PM_{10} hourly concentration in Kuala Lumpur, were taken to estimate the parameters of the log normal distributions. These sets of data were taken over a one year period for year 1998. For PM_{10} data set in 1998, there were 80 missing values. Missing values were replaced as they can affect the result in statistical analysis. The methods used to replace the missing values in the data set were: all missing values were filled with average of all data available above the missing values; all missing values were filled with average of all data available above and below missing values.

METHODOLOGY

The Log Normal Distribution

The probability density function (pdf) for the two parameter log normal distribution is expressed by;

$$f(x;\alpha,\beta) = \frac{1}{x\beta\sqrt{2\pi}}\exp\left[-\frac{1}{2}\left(\frac{\ln(x)-\alpha}{\beta}\right)^2\right], \alpha > 0 \text{ and } \beta > 0, \; x > 0 \qquad (1)$$

The cumulative distribution function is given by the following equation;

$$F(x;\alpha,\beta)=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\frac{\ln x-\alpha}{\beta}} e^{-\frac{x^2}{2}}dx, \alpha>0 \text{ and } \beta>0,\ x>0 \qquad (2)$$

where α is the scale parameter and β is the shape parameter.

Parameter Estimation

In this study, two methods were used to estimates α and β for the log normal distribution.

The method of maximum likelihood

For log-normal distribution, the likelihood function is defined as;

$$L=\prod_{i=1}^{n} f(x;\alpha,\beta)=\prod_{i=1}^{n}\frac{1}{x\beta\sqrt{2\pi}}\exp\left[-\frac{1}{2}\left(\frac{\ln(x)-\alpha}{\beta}\right)^2\right]$$

$$=\beta^{-n}(2\pi)^{-\frac{n}{2}}\prod_{i=1}^{n}x_i^{-1}\exp\left[-\frac{1}{2}\sum_{i=1}^{n}\left(\frac{\ln(x_i)-\alpha}{\beta}\right)^2\right] \qquad (3)$$

and the log-likelihood function is;

$$\ln L=-n\ln\beta-\frac{n}{2}\ln(2\pi)-\ln\left(\prod_{i=1}^{n}x_i\right)-\frac{1}{2}\sum_{i=1}^{n}\left(\frac{\ln x_i-\alpha}{\beta}\right)^2 \qquad (4)$$

Therefore, α and β are solutions of the derivatives of $\ln L$ with respect to α and β

$$\frac{\partial \ln L}{\partial \alpha}=0 \text{ and } \frac{\partial \ln L}{\partial \beta}=0$$

So, α is obtained as the solution of;

$$\alpha=\frac{1}{n}\sum_{i=1}^{n}\ln(x_i) \qquad (5)$$

and, $$\beta=\sqrt{\frac{1}{n}\sum_{i=1}^{n}\left[\ln(x_i)-\hat{\alpha}\right]^2} \qquad (6)$$

The method of moments

The moment estimates of the parameter of the log normal distribution are given by;

$$\mu=2\ln\mu'_1-\frac{1}{2}\ln\mu'_2 \qquad (7)$$

and;

$$\sigma^2 = \ln \mu'_2 - 2\ln \mu'_1 \quad (8)$$

where; $\mu'_1 = \frac{1}{n}\sum_{i=1}^{n} x_i$ and $\mu'_2 = \frac{1}{n}\sum_{i=1}^{n} x_i^2$

Then, by substituting sample estimates, $\bar{x}$ and s^2 for the mean and variance, respectively, the parameter of the log-normal distribution can be obtained;

$$\alpha = \sqrt{\ln\left[\mu_2 + (\mu'_1)^2\right] - 2\ln(\mu'_1)} \quad (9)$$

with $\beta = \ln(\mu'_1) - \frac{\alpha^2}{2}$ (10)

where μ'_1 and μ_2 are the mean and variance of data;

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \text{ and } s^2 = \sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{(n-1)}$$

RESULTS AND DISCUSSION

Estimation of α and β Values

The α and β values derived from data for PM_{10} in 1998 are given in Table 1. From the Table, it can be seen that even though there were two different methods used for replacing missing values, the values obtained for α and β , are quite similar.

Comparison of Two Parametric Estimating Methods

Figure 1 show an illustration of cdf plot for log-normal distribution using Alpha (A) and Beta (A) for PM_{10} in 1998. with different methods of parameter estimation. Two methods, maximum likelihood method and method of moments were used to estimate parameters for the log-normal distribution. The values of estimated parameter are given in Table 1. For log-normal distribution using PM_{10} data in 1998, there is not much different between MLE and method of moments for estimating the parameter.

Table 1. Estimation of α and β values for PM_{10} in 1998

Parameter Estimation	Data			
	Alpha (A)	Alpha (B)	Beta (A)	Beta (B)
MLE	4.137	4.135	0.452	0.453
Moments	4.140	4.140	0.430	0.431

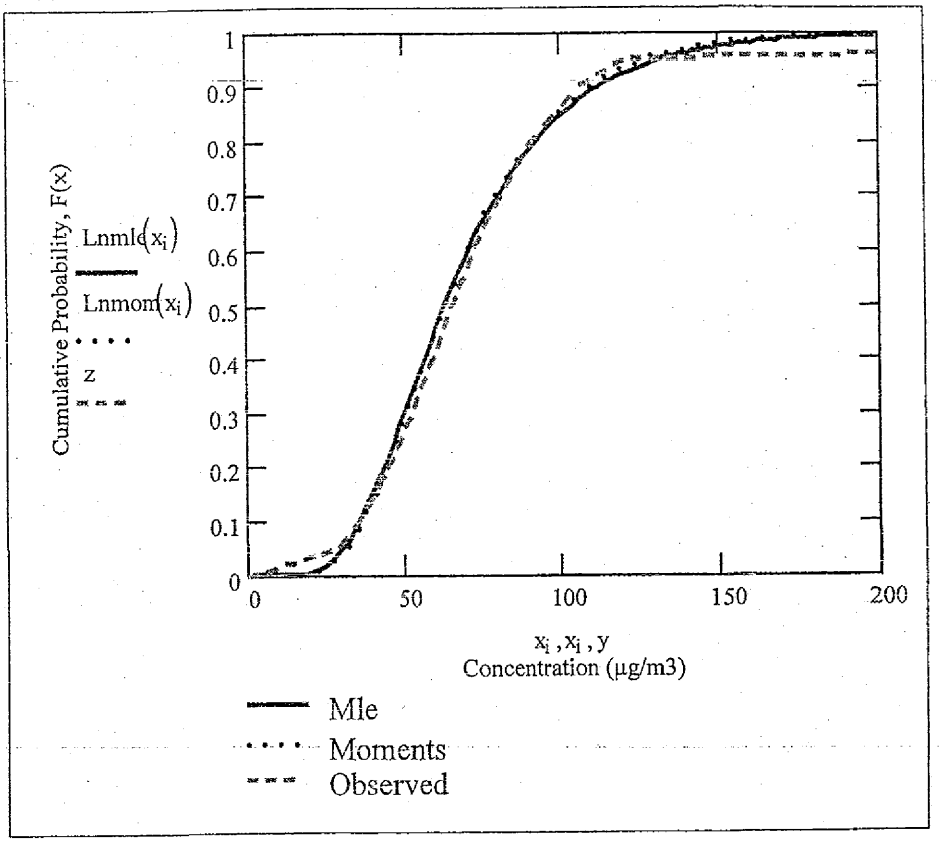


Figure 1. cdf plot for log-normal distribution with comparison between maximum likelihood method, method of moments and observed data (PM_{10} in 1998)

Prediction of the Probability Exceeding the Malaysia Ambient Quality Standards

Figures 2a and b show the pdf for PM_{10} concentration in Kuala Lumpur for the years 1998. The values of estimated parameters are $\alpha = 4.140$, $\beta = 0.430$ for PM_{10} in 1998 using method of moments. Even though the pdf plot for PM_{10} in 1998 showed approximately similar distribution, the distribution using Method of Moment gives better fit compared to the MLE especially at higher PM_{10} concentrations. From Figures 2a & b, it is found that the probabilities for PM_{10} concentration in 1998 exceeding Malaysia Ambient Quality Standard (>150 $\mu g/m^3$) are 0.027. It means that the number of days for PM_{10} exceeding the Malaysia Ambient Quality Standards for years 1999 is 10.

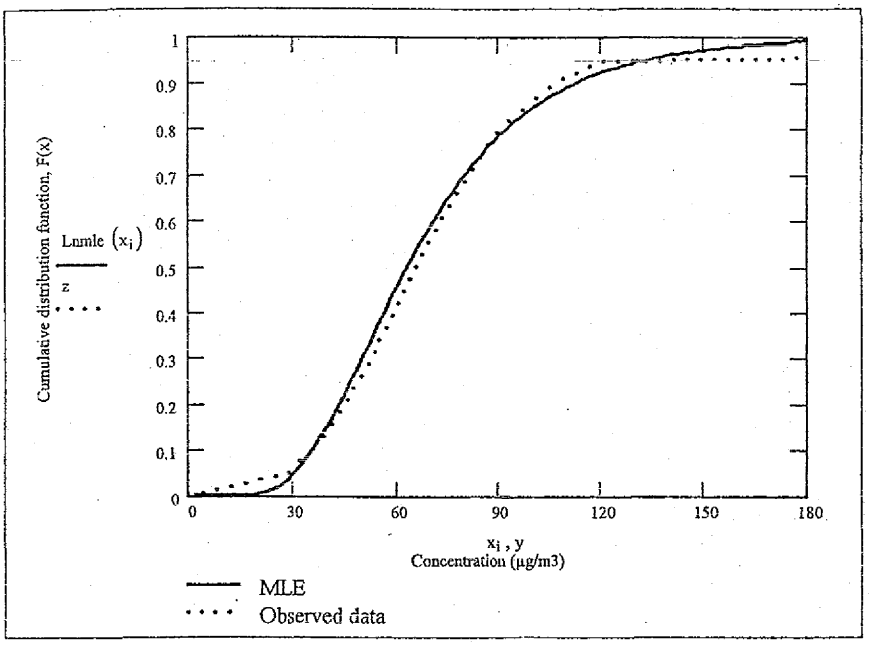


Figure 2a. cdf plot for log-normal distribution with comparison between maximum likelihood method and observed data (PM_{10} in 1998)

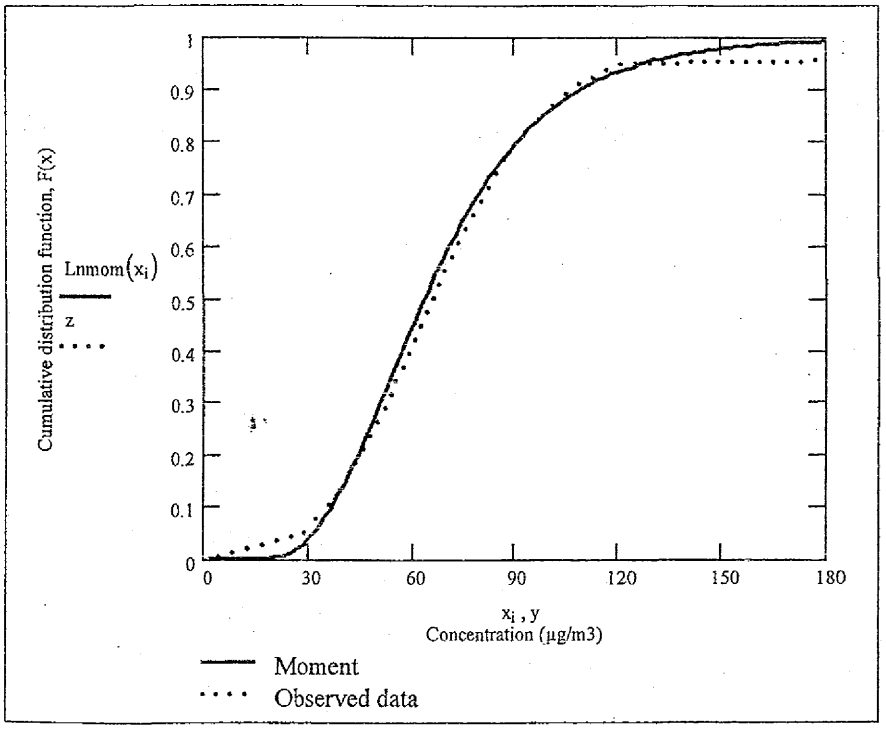


Figure 2b. cdf plot for log-normal distribution with comparison between method of moments and observed data (PM_{10} in 1998)

CONCLUSION

The result of this work shows that the PM_{10} concentration distribution can be represented by log-normal distribution. Between the two parametric estimating methods, there is not much different. For that method of moments with $\alpha = 4.140$, $\beta = 0.430$ for PM_{10} in 1998. The probabilities exceeding Malaysia Ambient Quality Standards are predicted by the log-normal distribution for PM_{10} concentration. The probability exceeding Malaysia Ambient Quality Standard for PM_{10} concentration in 1998 is 0.027. It means that the number of days for PM_{10} exceeding the Malaysia Ambient Quality Standards for 1998 would be 10 days.

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Tarikh : 18/5/2005

Pensyarah
Pusat Pengajian Kejuruteraan Awam
Kampus Kejuruteraan, Universiti Sains Malaysia
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
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Kampus Kejuruteraan, Universiti Sains Malaysia
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
Tel: 04-5937788 Faks: 04-5941009

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Pensyarah
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Kampus Kejuruteraan, Universiti Sains Malaysia
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
Tel: 04-5937788 Faks: 04-5941009

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Tarikh 25/5/05

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PULAU PINANG
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Pensyarah
Pusat Pengajian Kejuruteraan Awam
Kampus Kejuruteraan, Universiti Sains Malaysia
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
Tel: 04-5937788 Faks: 04-5941009

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Pensyarah
Pusat Pengajian Kejuruteraan Awam
Kampus Kejuruteraan, Universiti Sains Malaysia
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
el: 04-5937788 Faks: 04-5941009

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Tarikh : 18/5/2006

NOR AZAM BIN RAMLI
Pensyarah
Pusat Pengajian Kejuruteraan Awam
Kampus Kejuruteraan, Universiti Sains Malaysia
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
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Pensyarah
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Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
Tel: 04-5937788 Faks: 04-5941009

Nama Penyelia : NOR AZAM BIN RAMLI

Tarikh : 13/6/06.

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Kampus Kejuruteraan, Universiti Sains ...
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
Tel: 04-5937788 Faks: 04-5941009

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Nama Penyelia :

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Pusat Pengajian Kejuruteraan Awam
Kampus Kejuruteraan, Universiti Sains Malaysia
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
Tel: 04-5937788 Faks: 04-5941009

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Pensyarah
Pusat Pengajian Kejuruteraan Awam
Kampus Kejuruteraan, Universiti Sains Malaysia
Seri Ampangan, 14300 Nibong Tebal
PULAU PINANG
Tel: 04-5937788 Faks: 04-5941009

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Kampus Kejuruteraan, Universiti Sains Malaysia
Sen Ampangan, 14300 Nibong Tebal
PULAU PINANG
Tel: 04-5937788 Faks: 04-5941009

Saya : MOHAMED HASNAIN ISA
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Mengesahkan bahawa saya telah menyemak tesis ini dan berpuashati/tidak berpuashati bahawa pelajar telah membuat semua pembetulan seperti disyaratkan oleh Lembaga Pemeriksa Tesis yang telah bersidang pada :

18-05-2005
Tarikh

Tandatangan Pemeriksa Dalam

PUSAT PENGAJIAN KEJ. AWAM * UNIVERSITI SAINS MALAYSIA *
Diterima: Tarikh: 19/5/05 Oleh:

/rr

PUSAT PENGAJIAN KEJURUTERAAN AWAM
KAMPUS KEJURUTERAAN
UNIVERSITI SAINS MALAYSIA

BORANG PENGESAHAN STATUS TESIS

TAJUK TESIS : AIR POLLUTION EMISSION CONTROL OF A CRUDE PALM OIL FACTORY

Saya : LIM SEANG JOO
(HURUF BESAR)

mengaku bahawa saya telah membuat pembetulan terhadap keseluruhan tesis ini seperti disyaratkan oleh penyelia.

Tandatangan Pelajar :

Disahkan Oleh:

(Tandatangan Penyelia)

Tarikh : 13 MAY 05

Nama Penyelia : HOK AZAM RAMLI

Tarikh : 14/05/05

Saya : MOHAMED HASNAIN ISA
NAMA PEMERIKSA DALAM (HURUF BESAR)

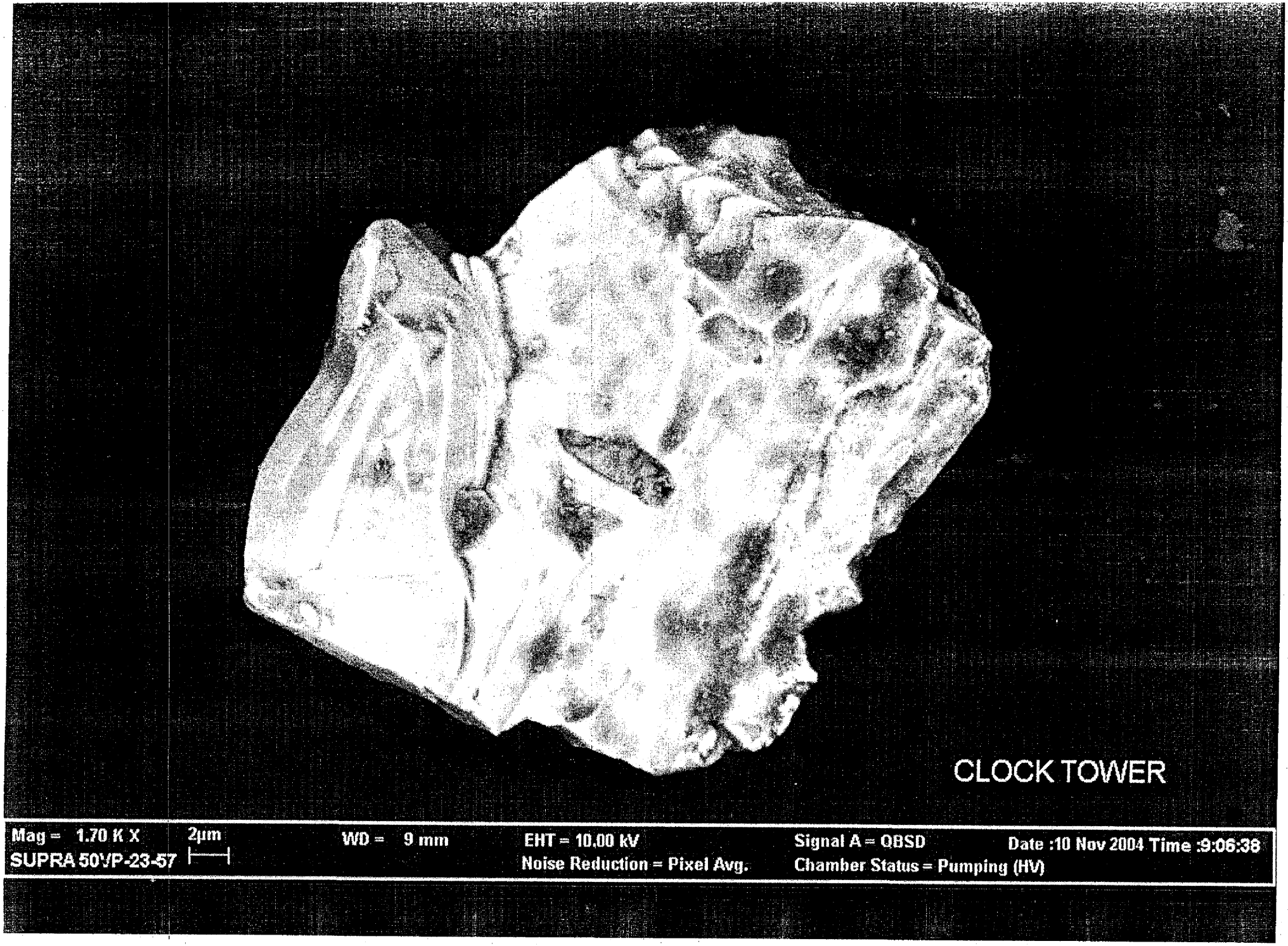
Mengesahkan bahawa saya telah menyemak tesis ini dan berpuashati/tidak berpuashati bahawa pelajar telah membuat semua pembetulan seperti disyaratkan oleh Lembaga Pemeriksa Tesis yang telah bersidang pada :

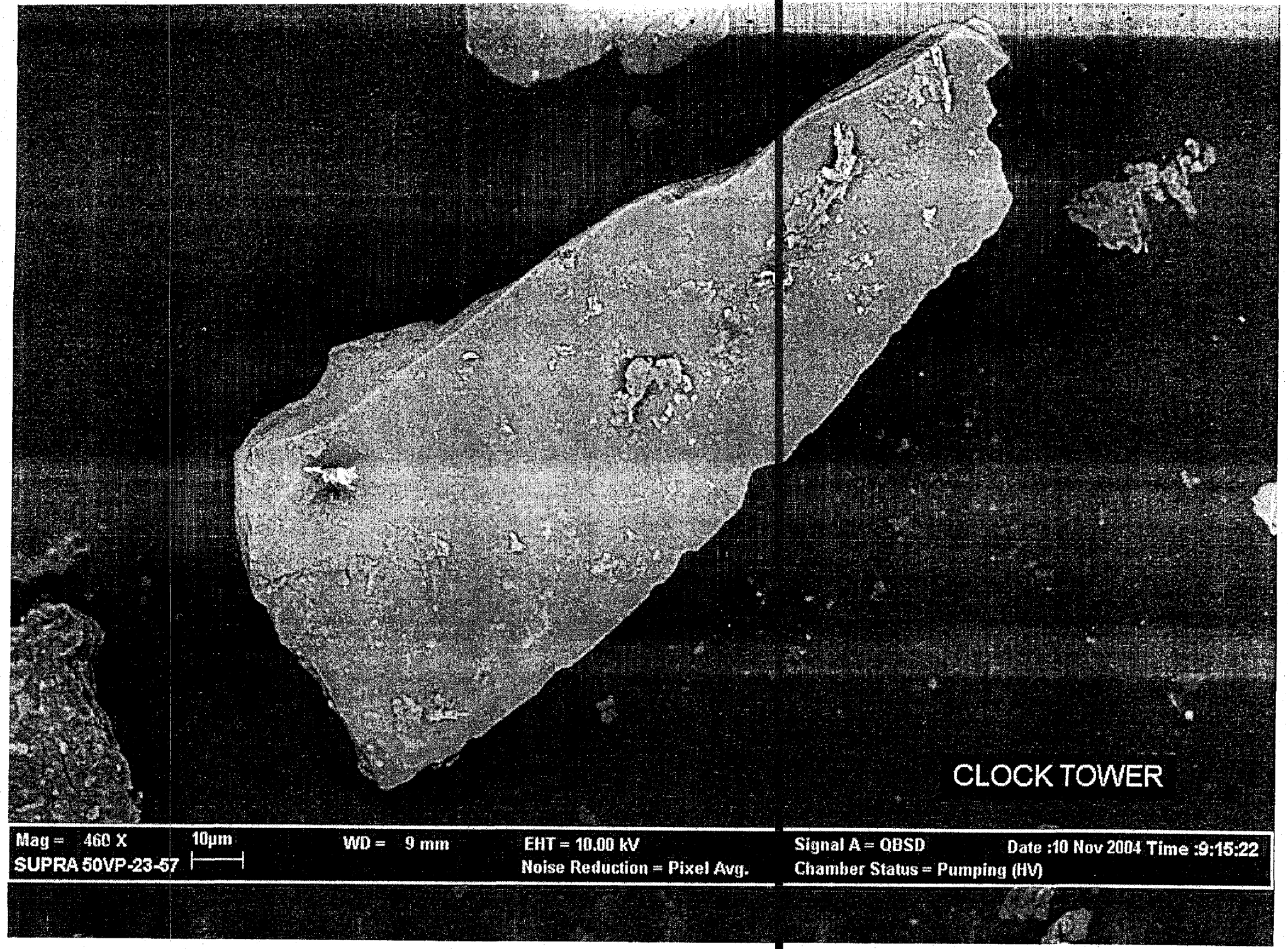
16-05-2005
Tarikh

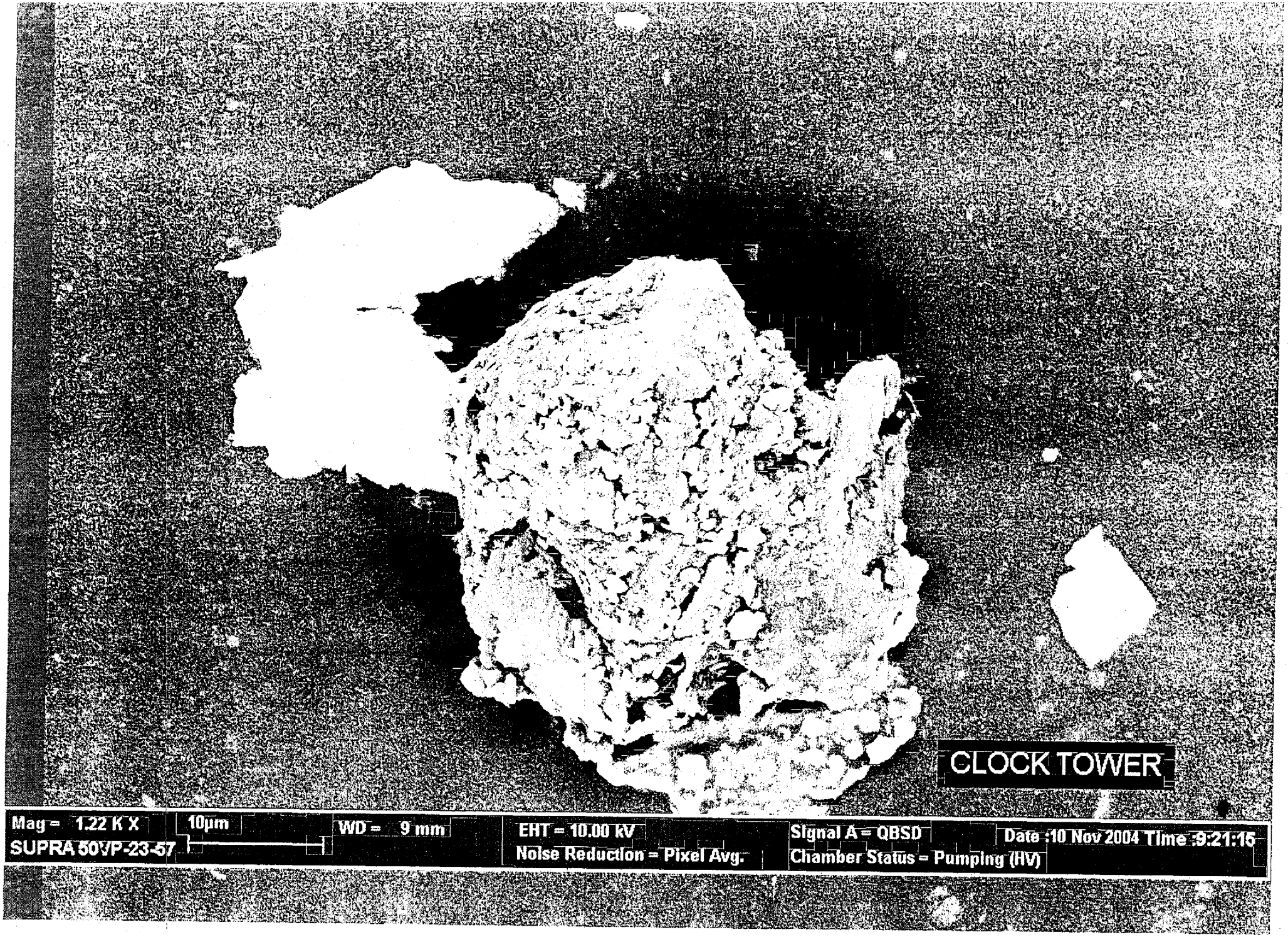
Tandatangan Pemeriksa Dalam

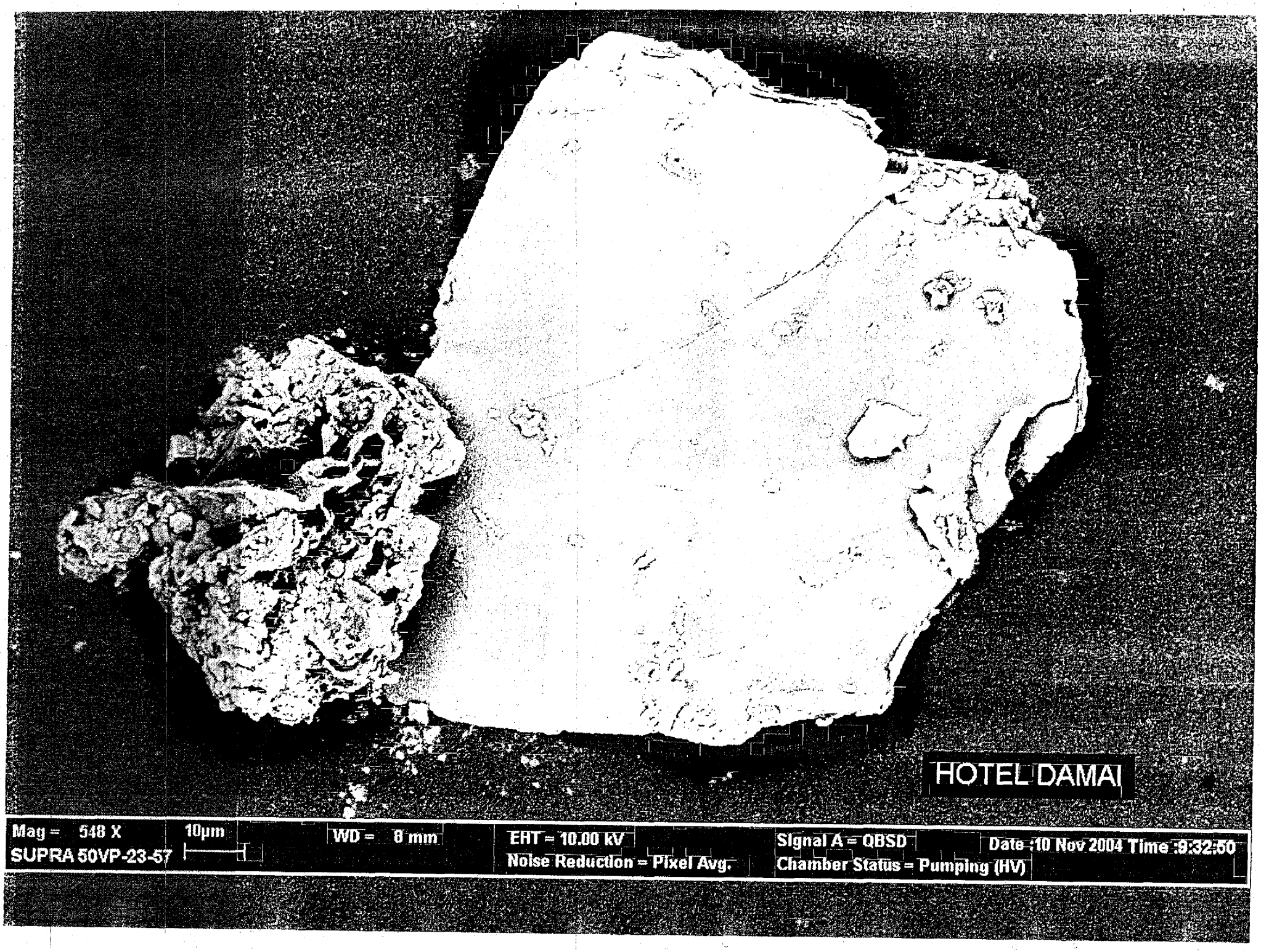
PUSAT PENGAJIAN KEJ. AWAM * UNIVERSITI SAINS MALAYSIA *
Diterima:
Tarikh: 17/5/05
Oleh:

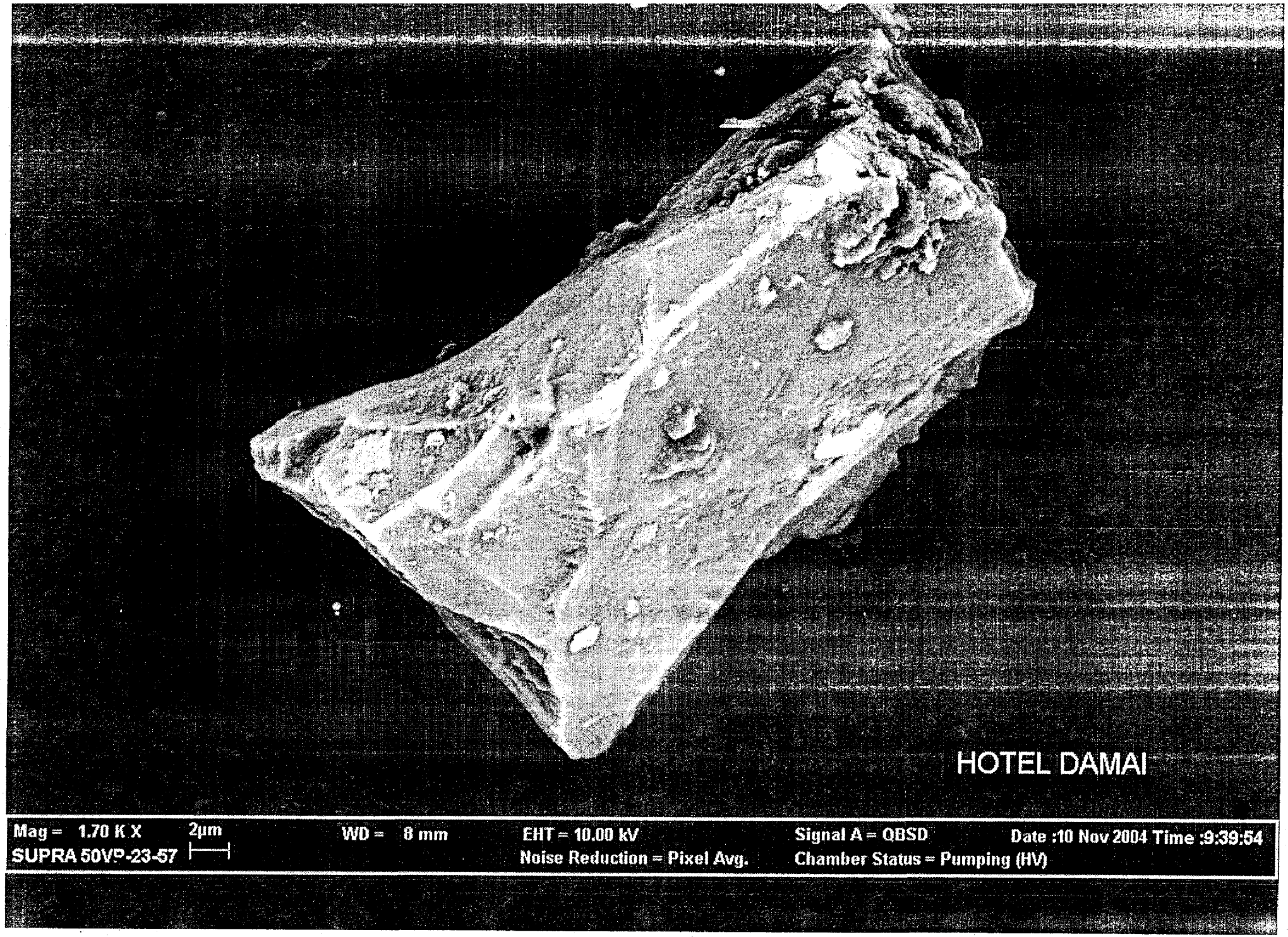
CONTOH IMEJ-IMEJ PARTIKEL

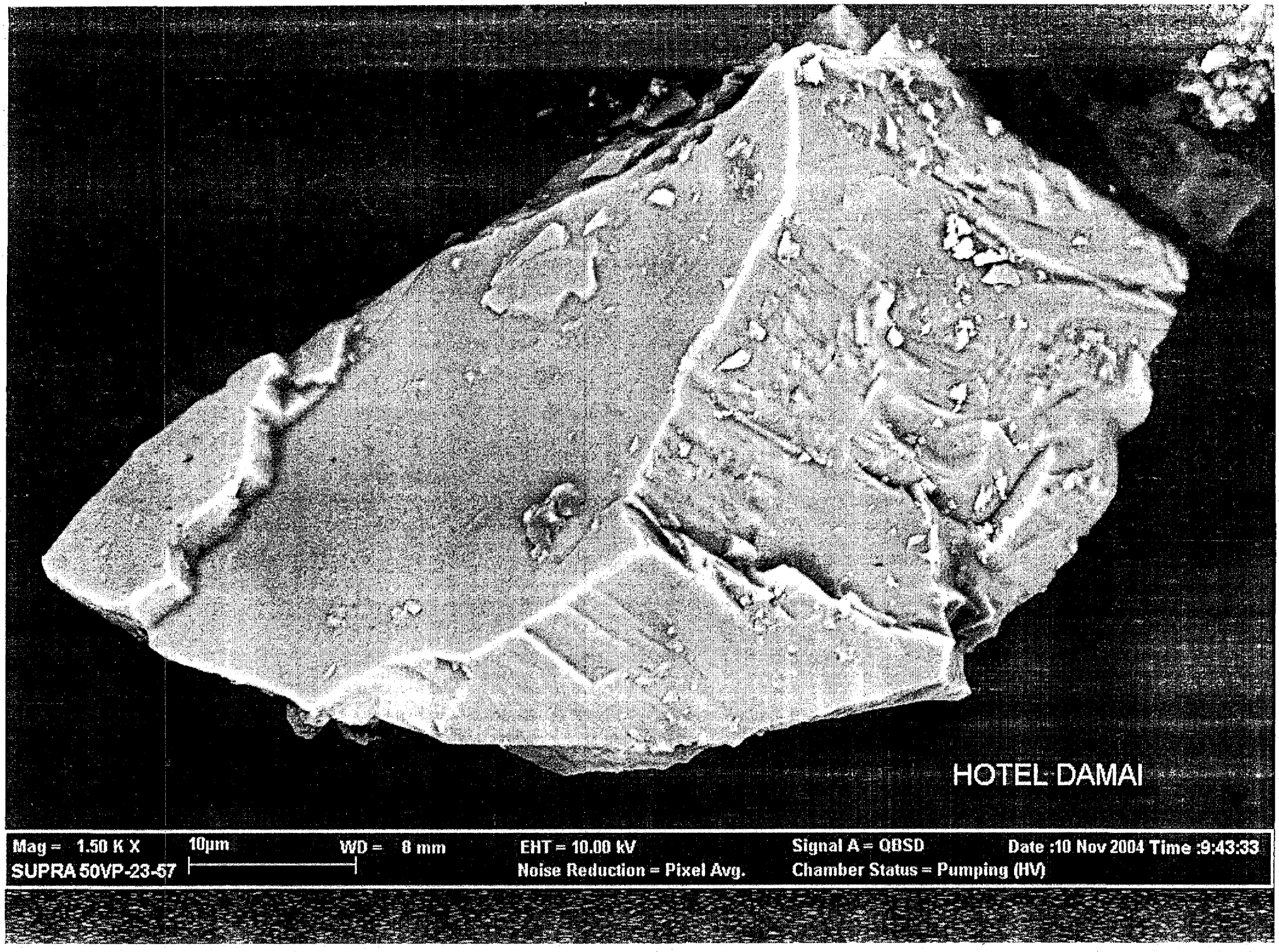

CLOCK TOWER
Mag = 1.70 K X
2µm
SUPRA 50VP-23-57
WD = 9 mm
EHT = 10.00 kV
Noise Reduction = Pixel Avg.
Signal A = QBSD
Chamber Status = Pumping (HV)
Date :10 Nov 2004 Time :9:06:38

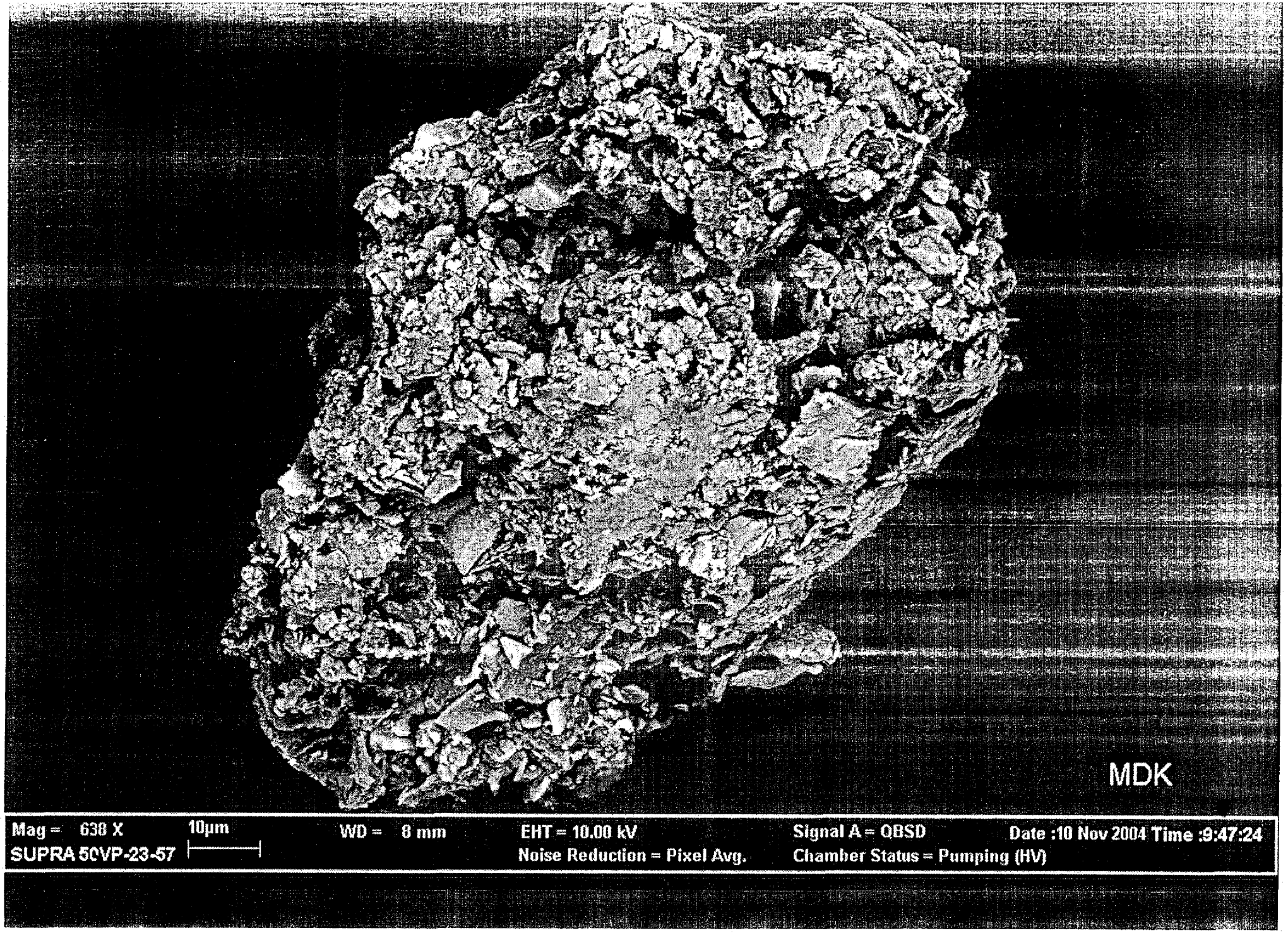

CLOCK TOWER
Mag = 460 X
10µm
WD = 9 mm
EHT = 10.00 kV
Noise Reduction = Pixel Avg.
SUPRA 50VP-23-57
Signal A = QBSD
Date :10 Nov 2004 Time :9:15:22
Chamber Status = Pumping (HV)

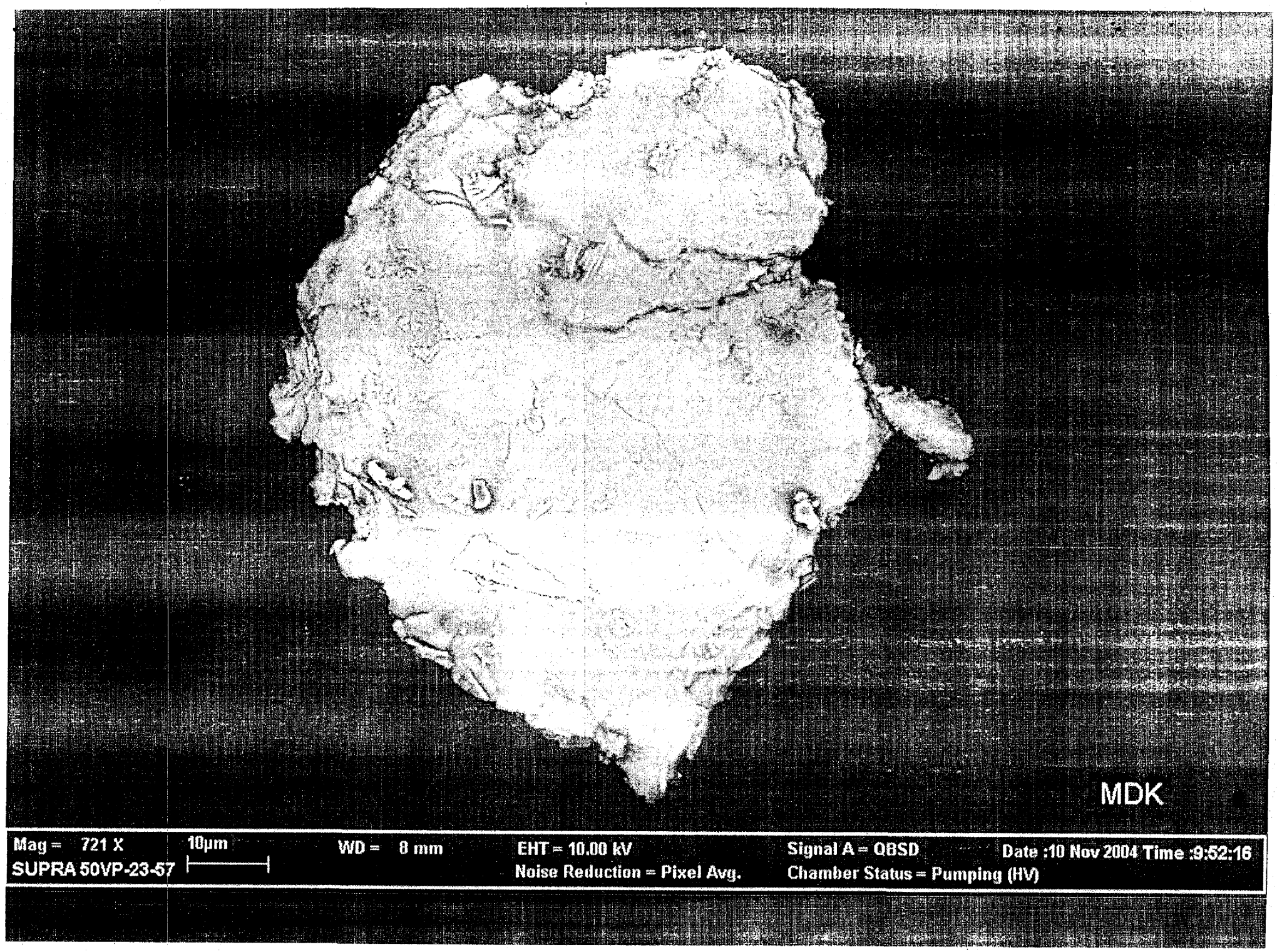

CLOCK TOWER
Mag = 1.22 K X
10µm
WD = 9 mm
SUPRA 50VP-23-57
EHT = 10.00 kV
Noise Reduction = Pixel Avg.
Signal A = QBSD
Chamber Status = Pumping (HV)
Date :10 Nov 2004 Time :9:21:15

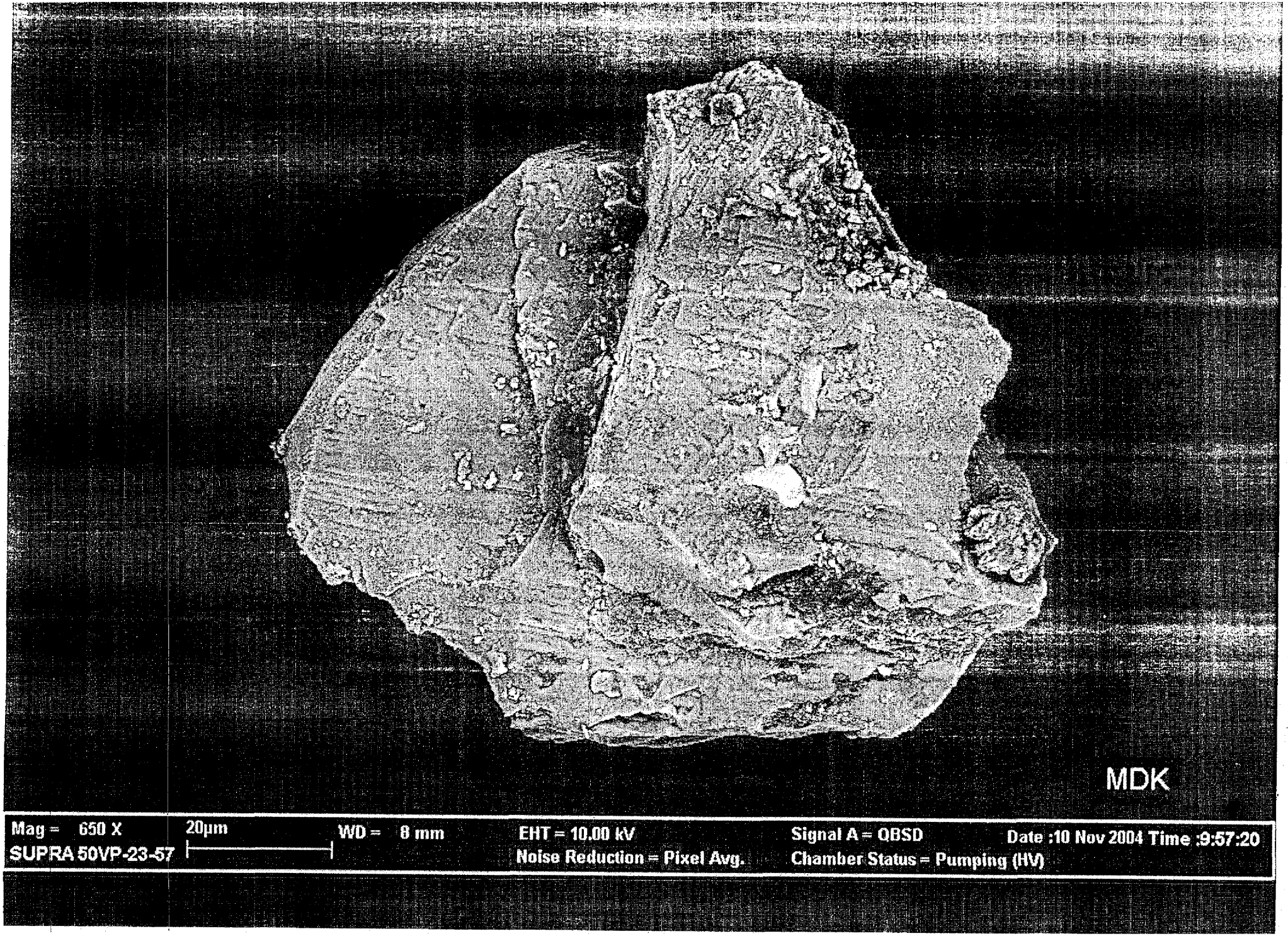

HOTEL DAMAI
Mag = 548 X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :9:32:50
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

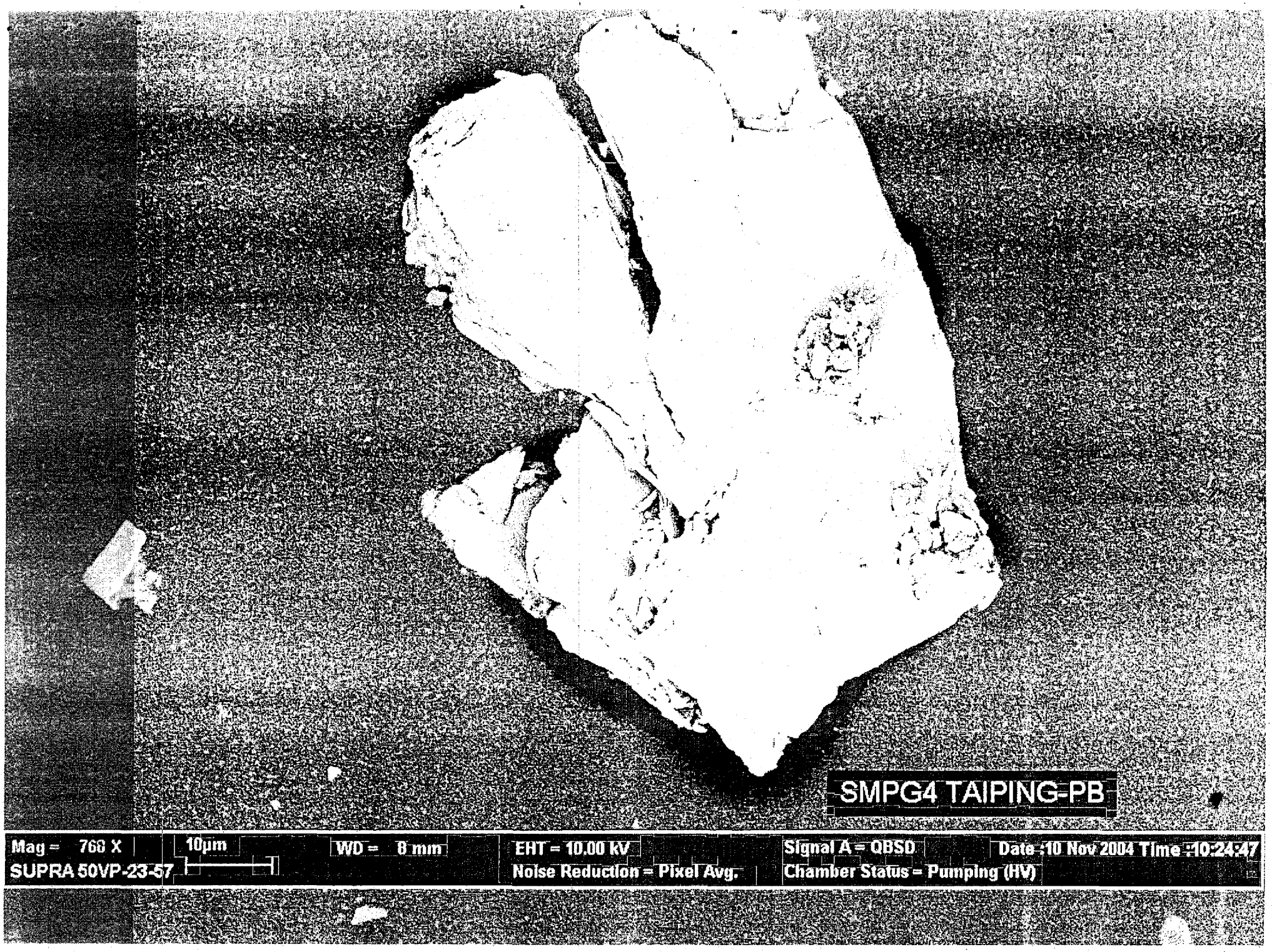

HOTEL DAMAI
Mag = 1.70 K X
2µm
SUPRA 50VP-23-57
WD = 8 mm
EHT = 10.00 kV
Noise Reduction = Pixel Avg.
Signal A = QBSD
Chamber Status = Pumping (HV)
Date :10 Nov 2004 Time :9:39:54

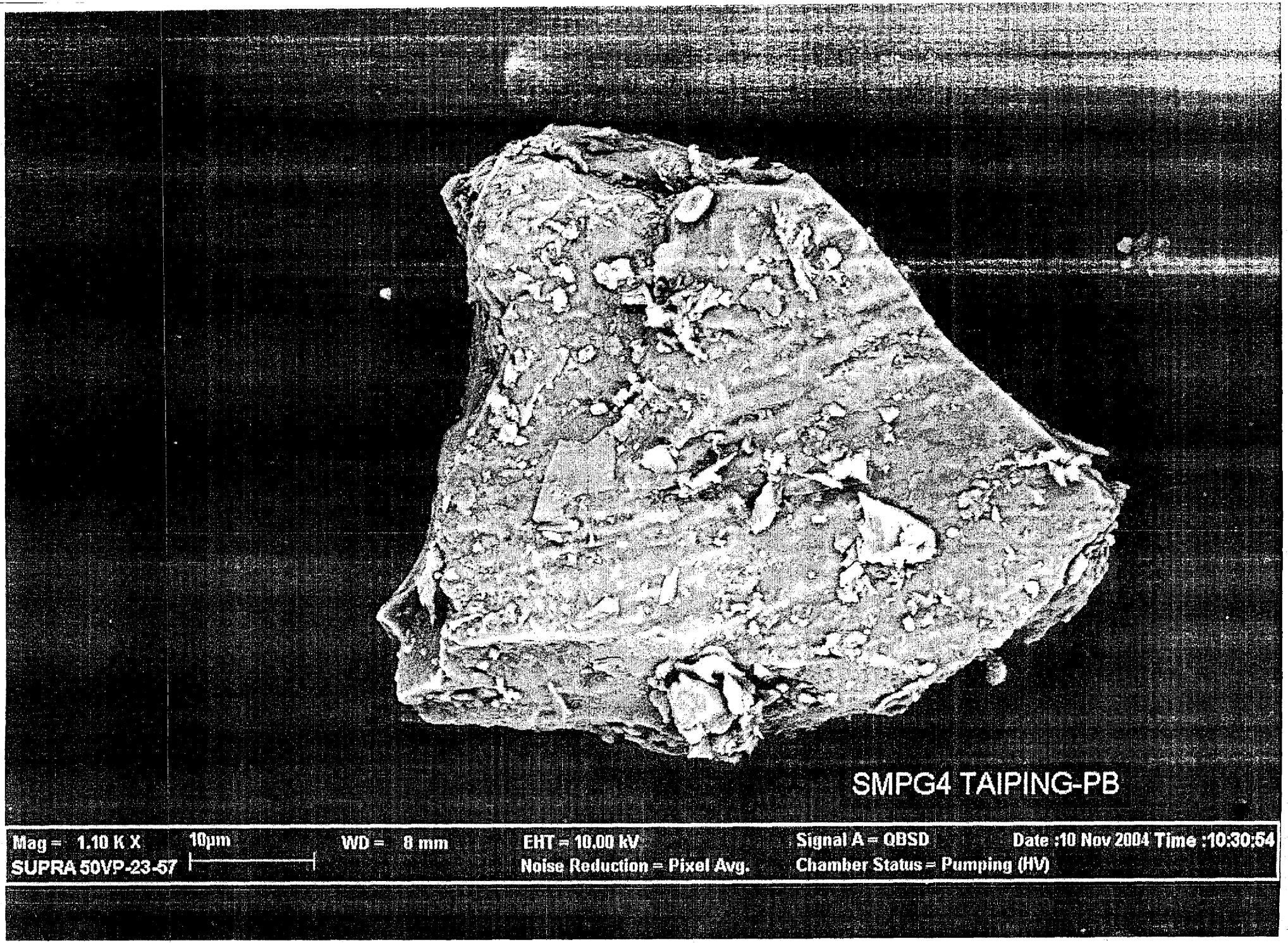

HOTEL DAMAI
Mag = 1.50 K X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :9:43:33
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

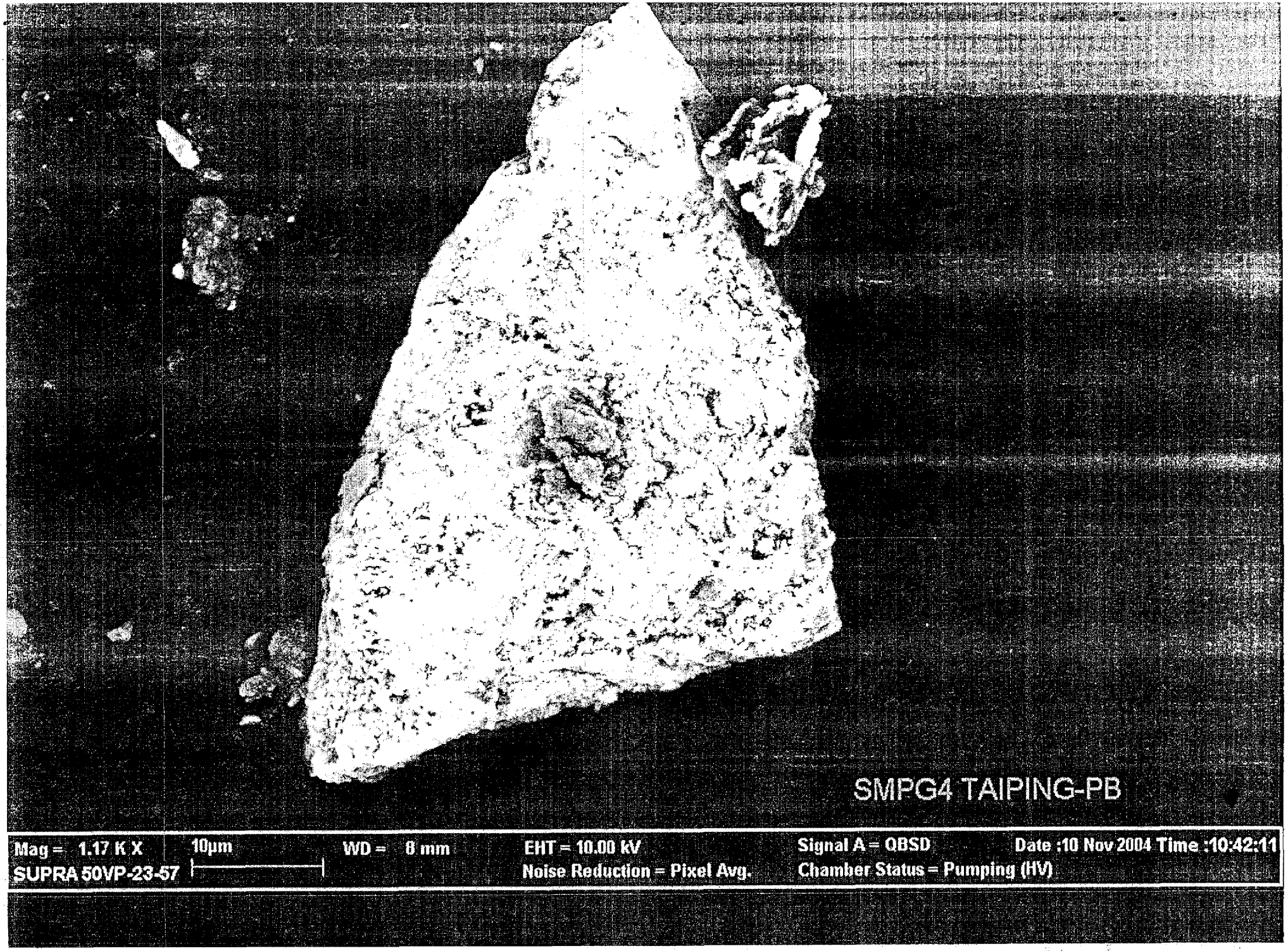

MDK
Mag = 638 X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :9:47:24
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

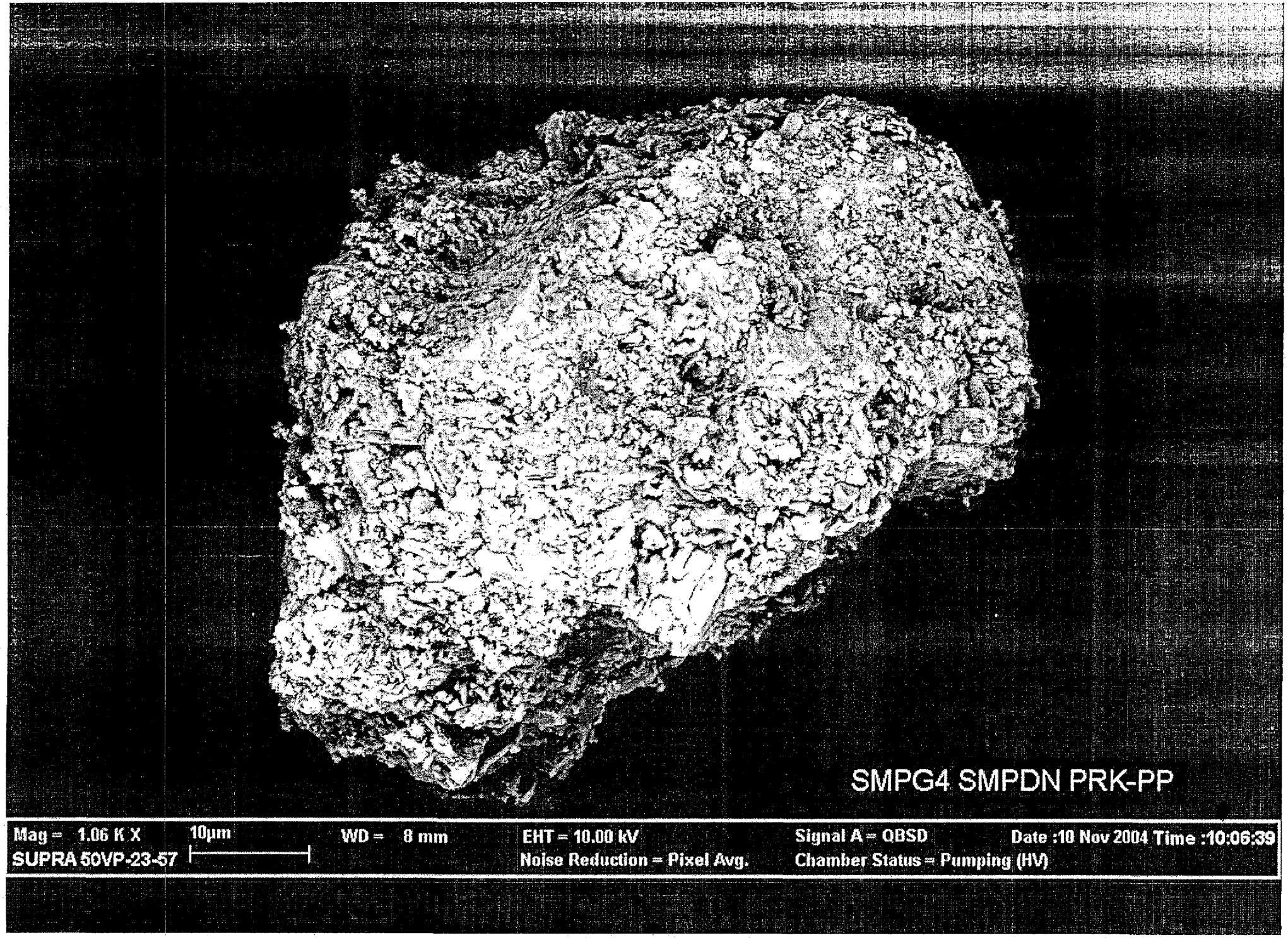

MDK
Mag = 721 X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :9:52:16
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

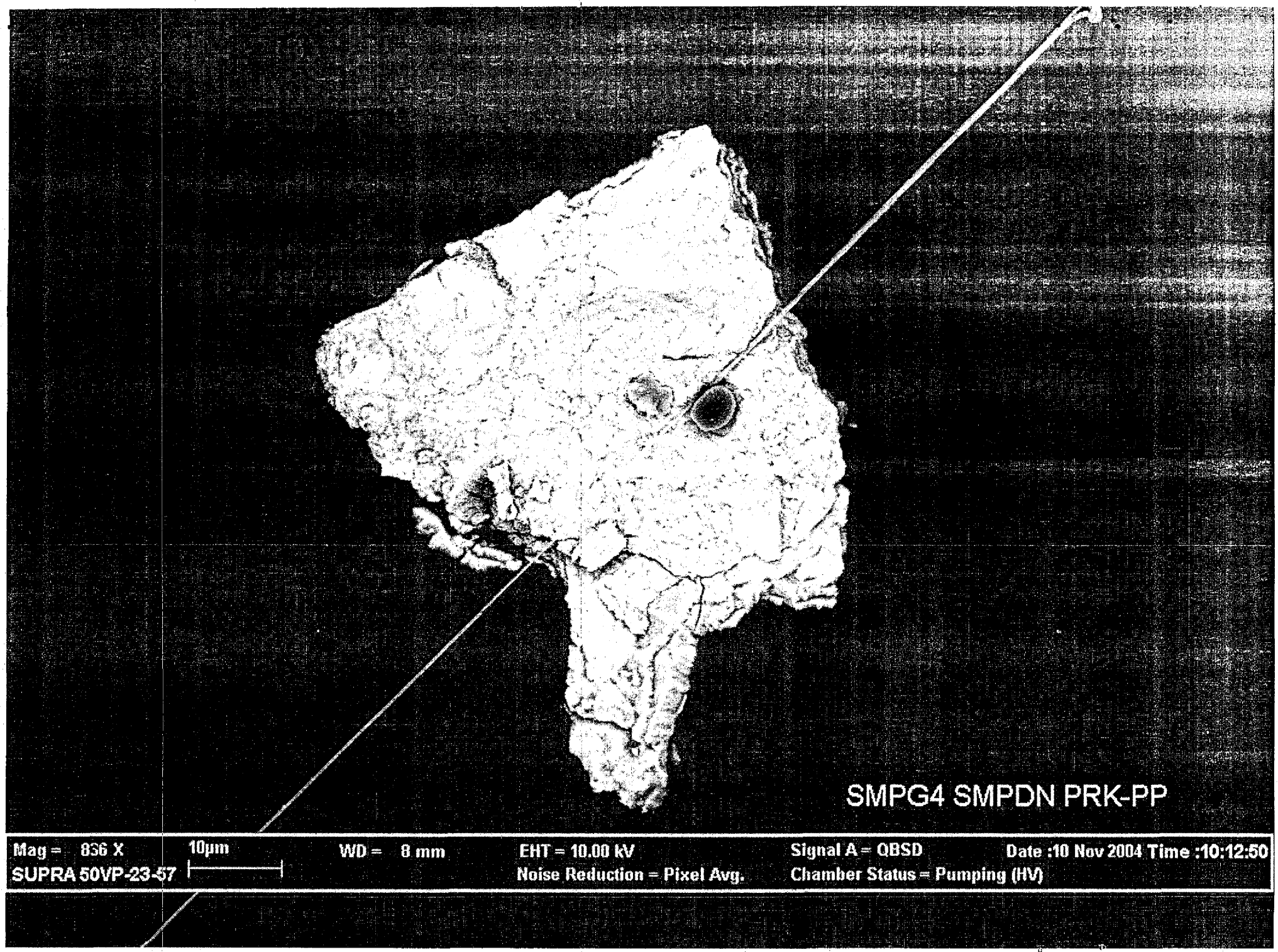

MDK
Mag = 650 X
20µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :9:57:20
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)


SMPG4 TAIPING-PB
Mag = 768 X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :10:24:47
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

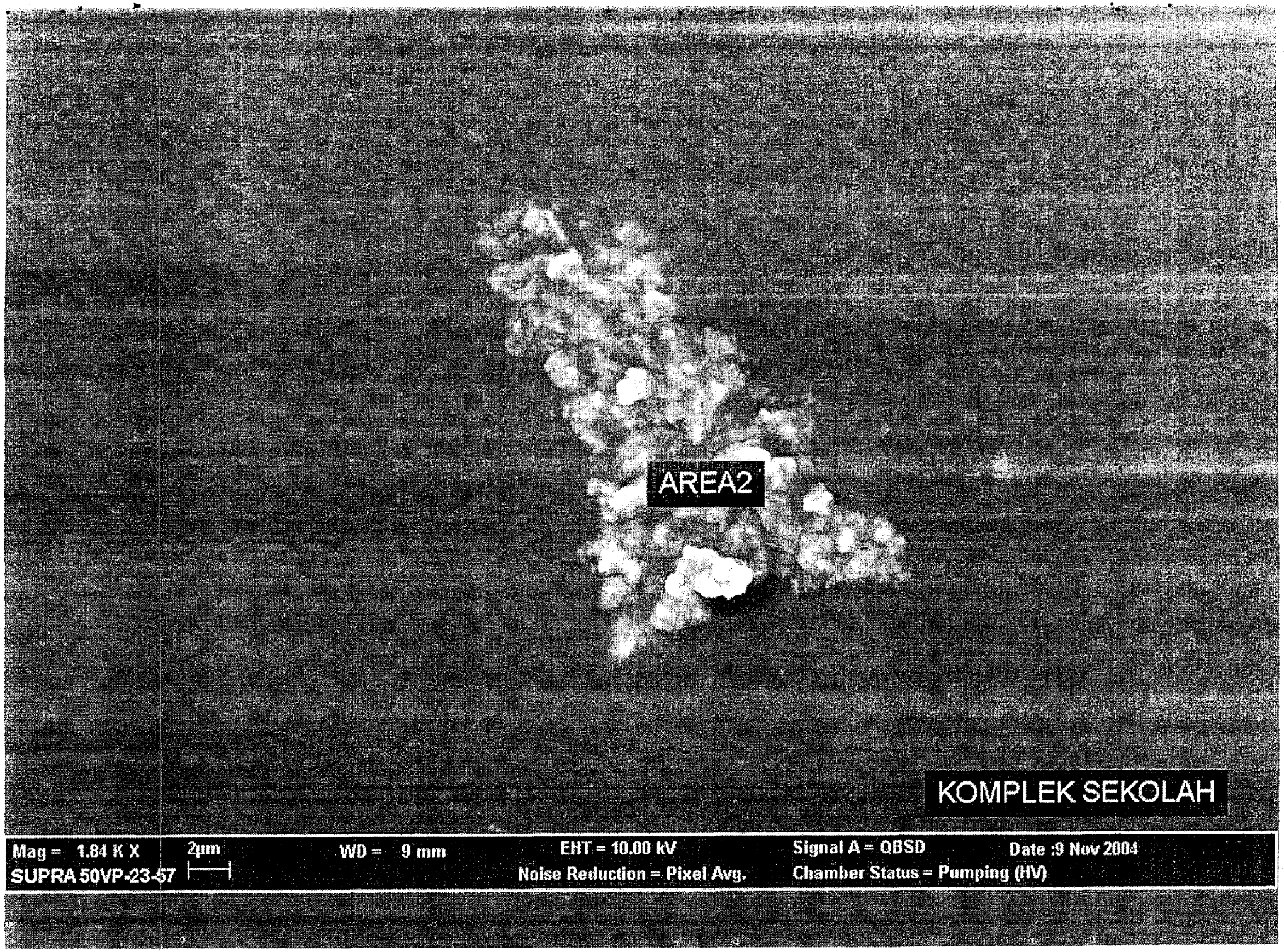

SMPG4 TAIPING-PB
Mag = 1.10 K X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :10:30:54
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

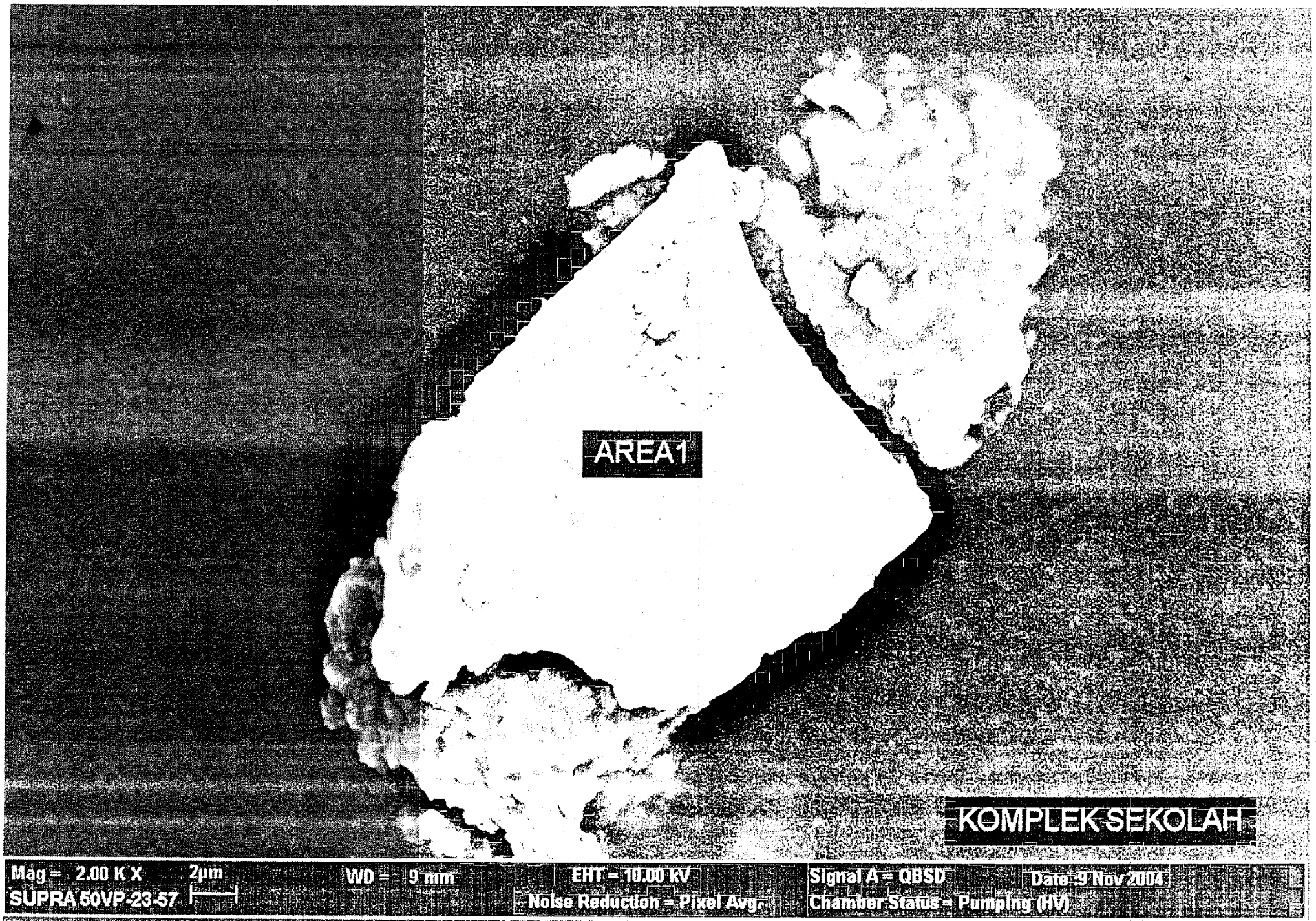

SMPG4 TAIPING-PB
Mag = 1.17 K X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :10:42:11
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

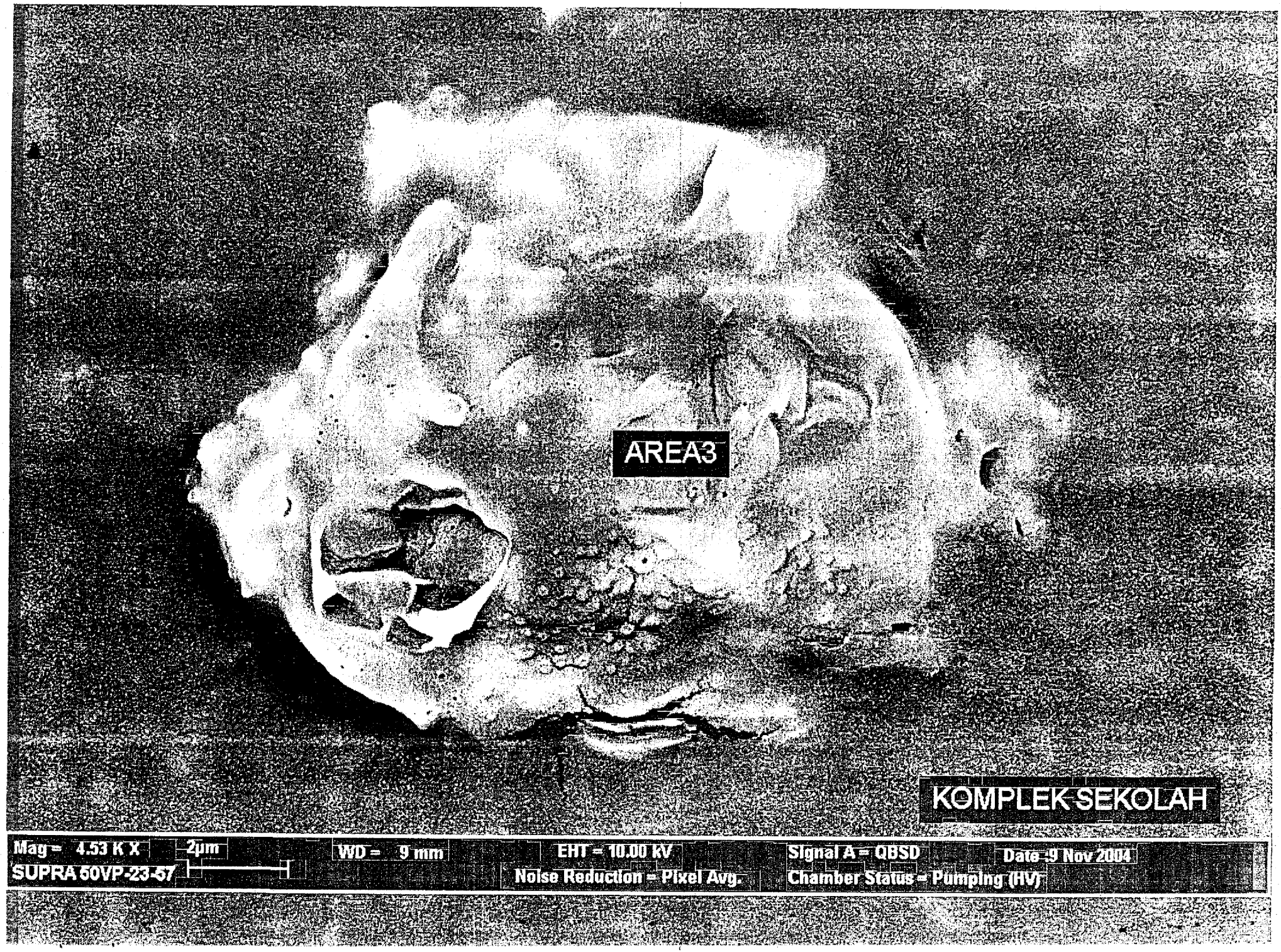

SMPG4 SMPDN PRK-PP
Mag = 1.06 K X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :10:06:39
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

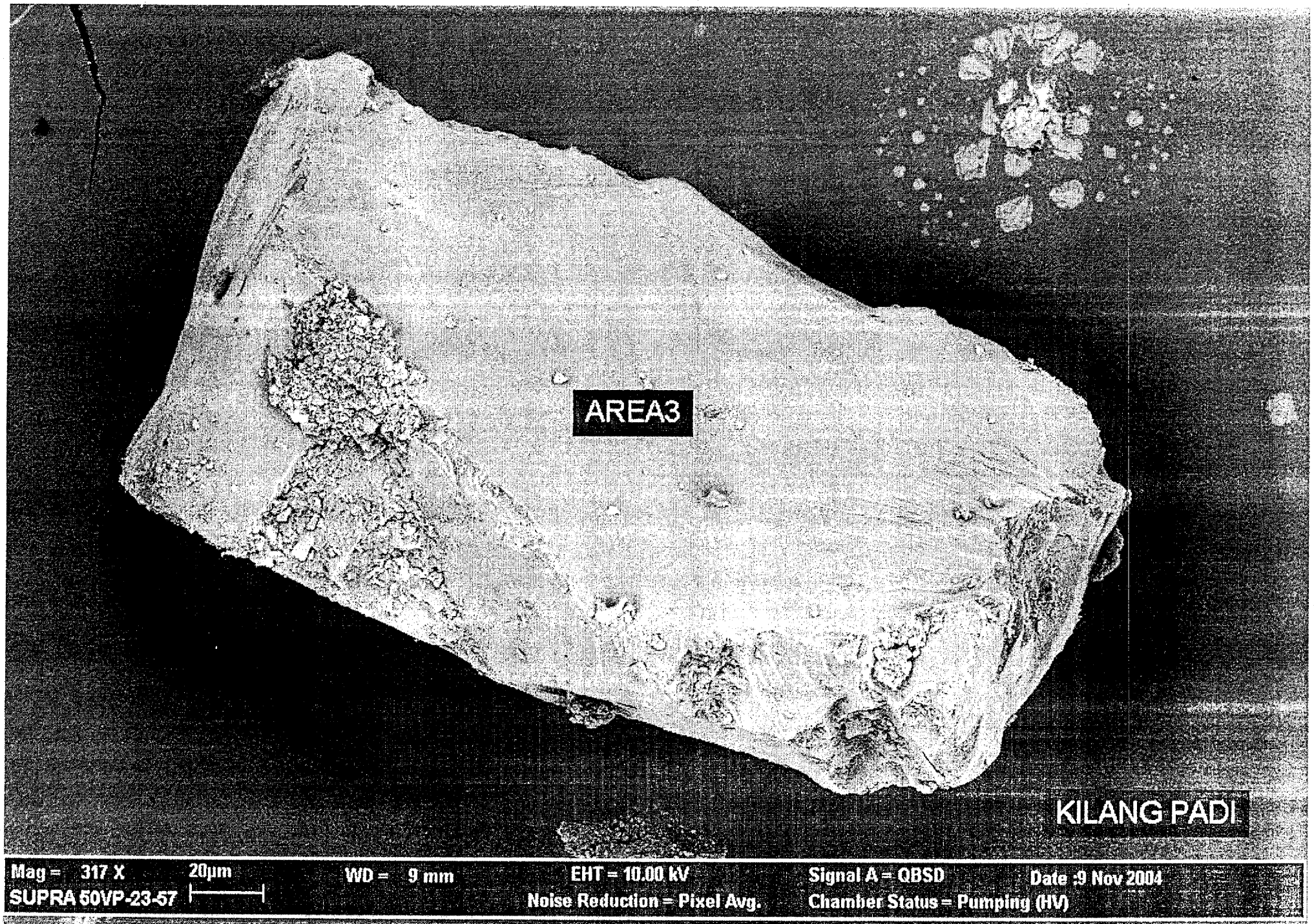

SMPG4 SMPDN PRK-PP
Mag = 836 X
10µm
WD = 8 mm
EHT = 10.00 kV
Signal A = QBSD
Date :10 Nov 2004 Time :10:12:50
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

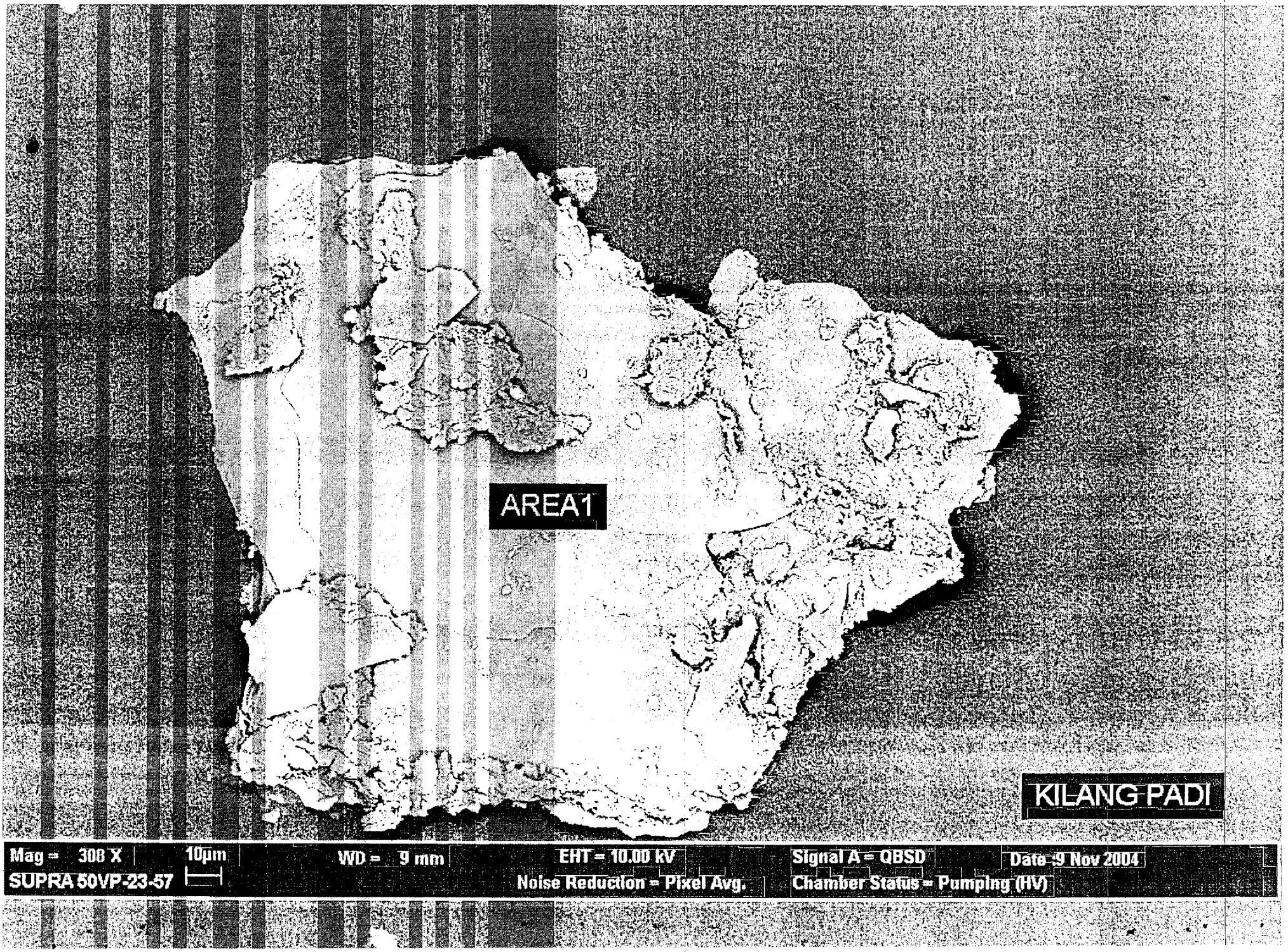

SMPG4 SMPDN PRK-PP
Mag = 571 X
20µm
WD = 8 mm
EHT = 10.00 kV
Noise Reduction = Pixel Avg.
Signal A = QBSD
Date :10 Nov 2004 Time :10:18:39
SUPRA 50VP-23-57
Chamber Status = Pumping (HV)

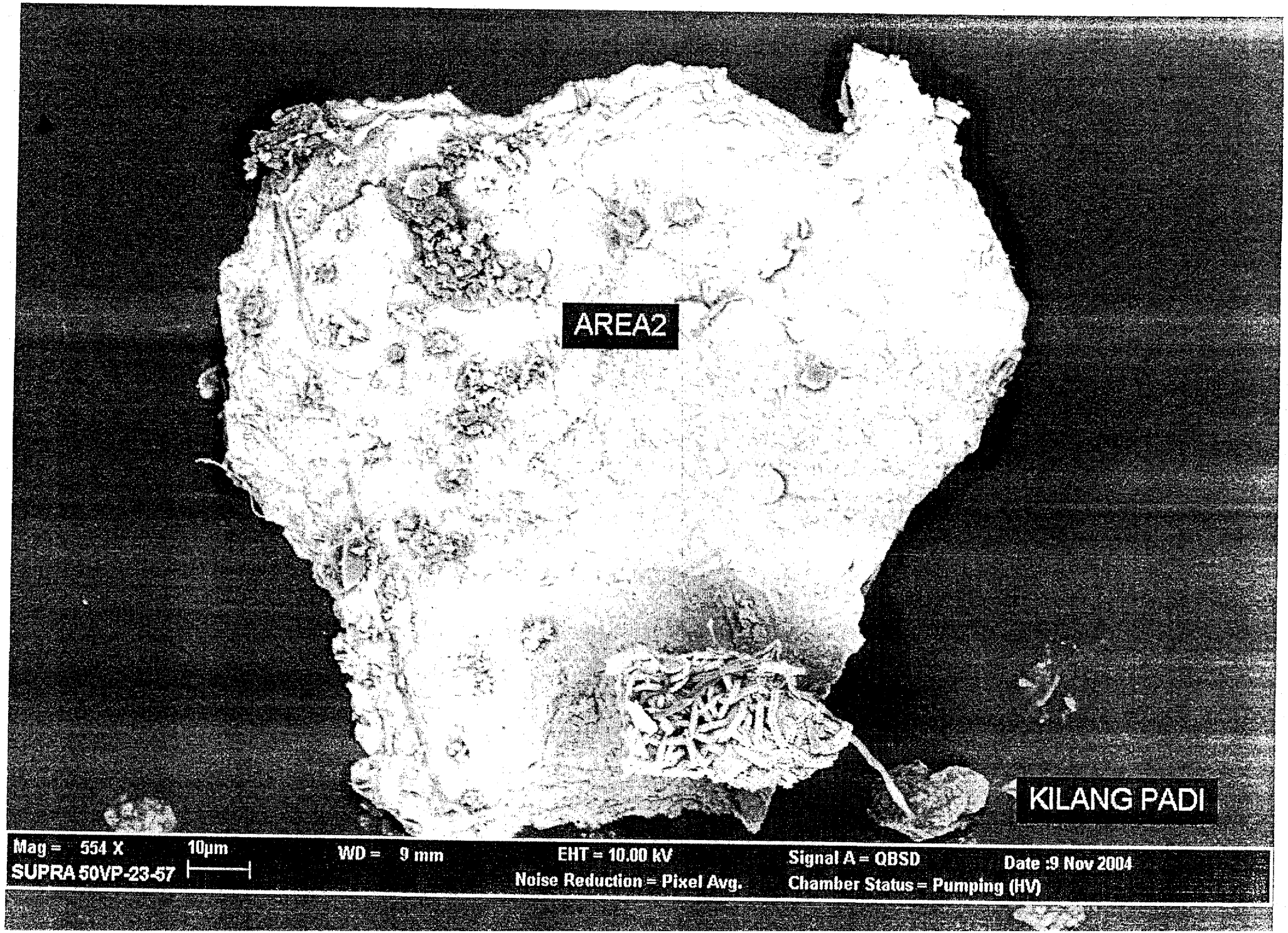

AREA2
KOMPLEK SEKOLAH
Mag = 1.84 K X
2µm
WD = 9 mm
EHT = 10.00 kV
Signal A = QBSD
Date :9 Nov 2004
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)

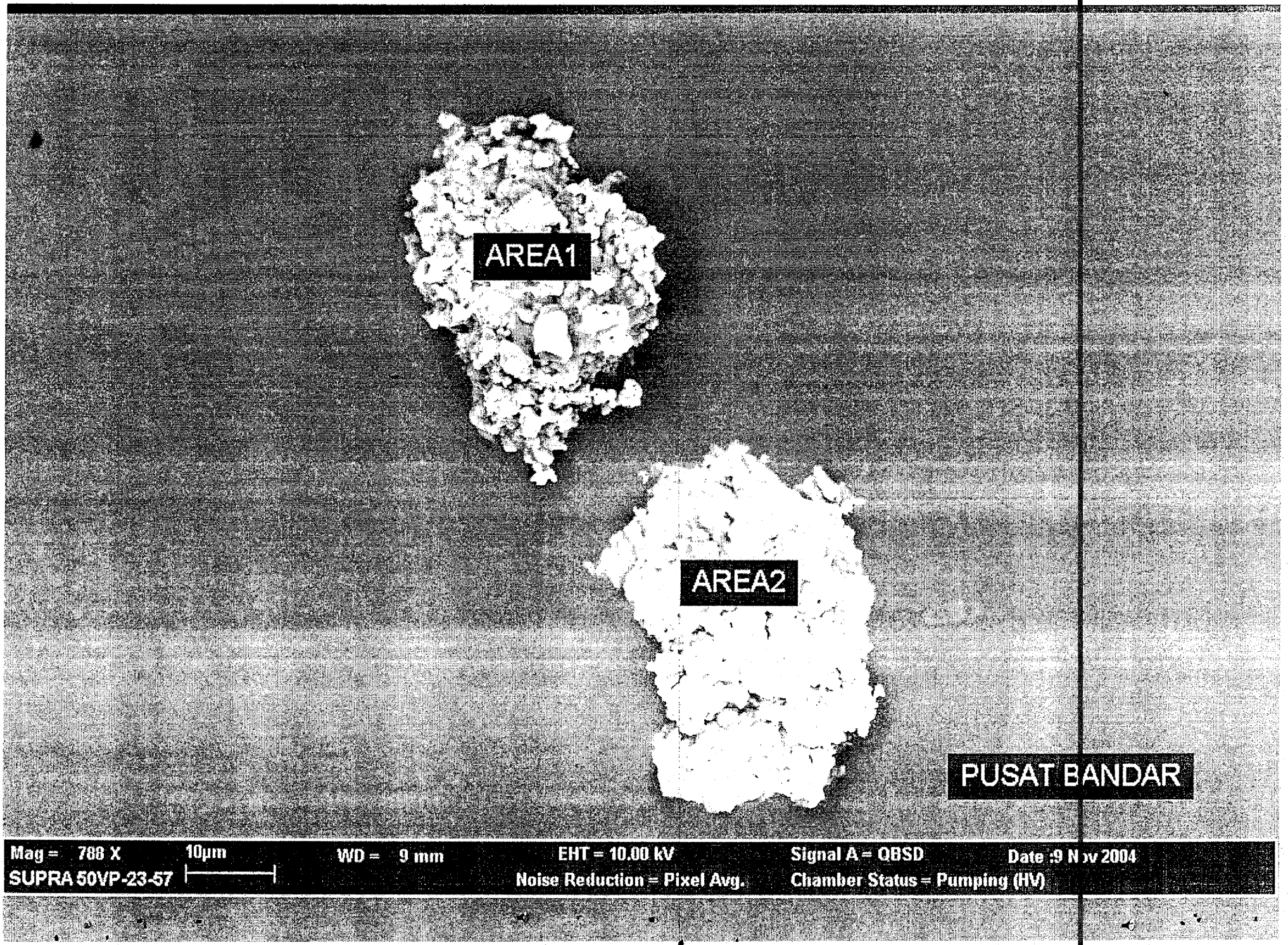

AREA1
KOMPLEK SEKOLAH
Mag = 2.00 K X
2µm
SUPRA 50VP-23-57
WD = 9 mm
EHT = 10.00 kV
Noise Reduction = Pixel Avg
Signal A = QBSD
Chamber Status = Pumping (HV)
Date :9 Nov 2004

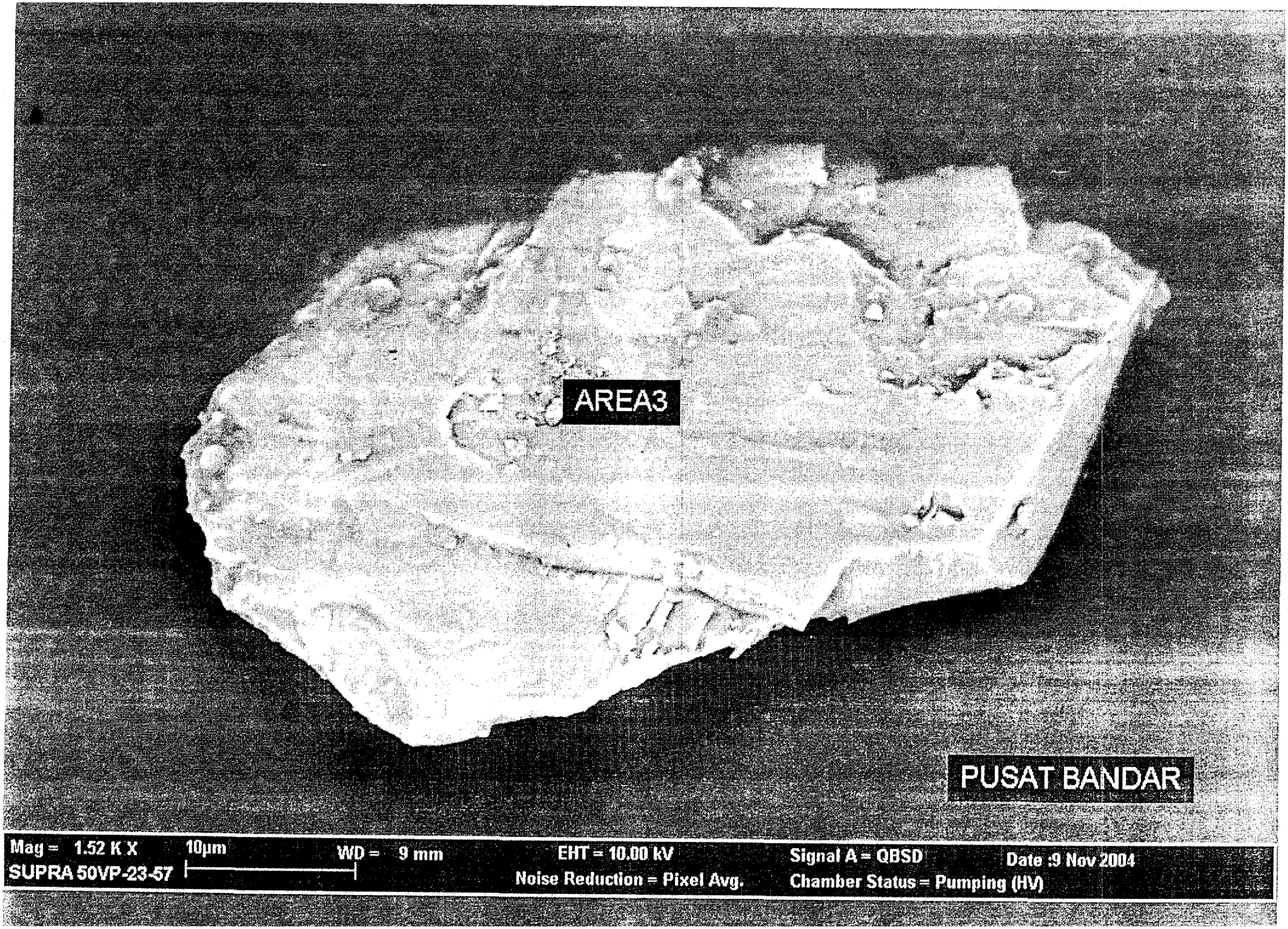

AREA3
KOMPLEK SEKOLAH
Mag = 4.53 K X
2µm
SUPRA 50VP-23-67
WD = 9 mm
EHT = 10.00 kV
Noise Reduction = Pixel Avg
Signal A = QBSD
Date :9 Nov 2004
Chamber Status = Pumping (HV)

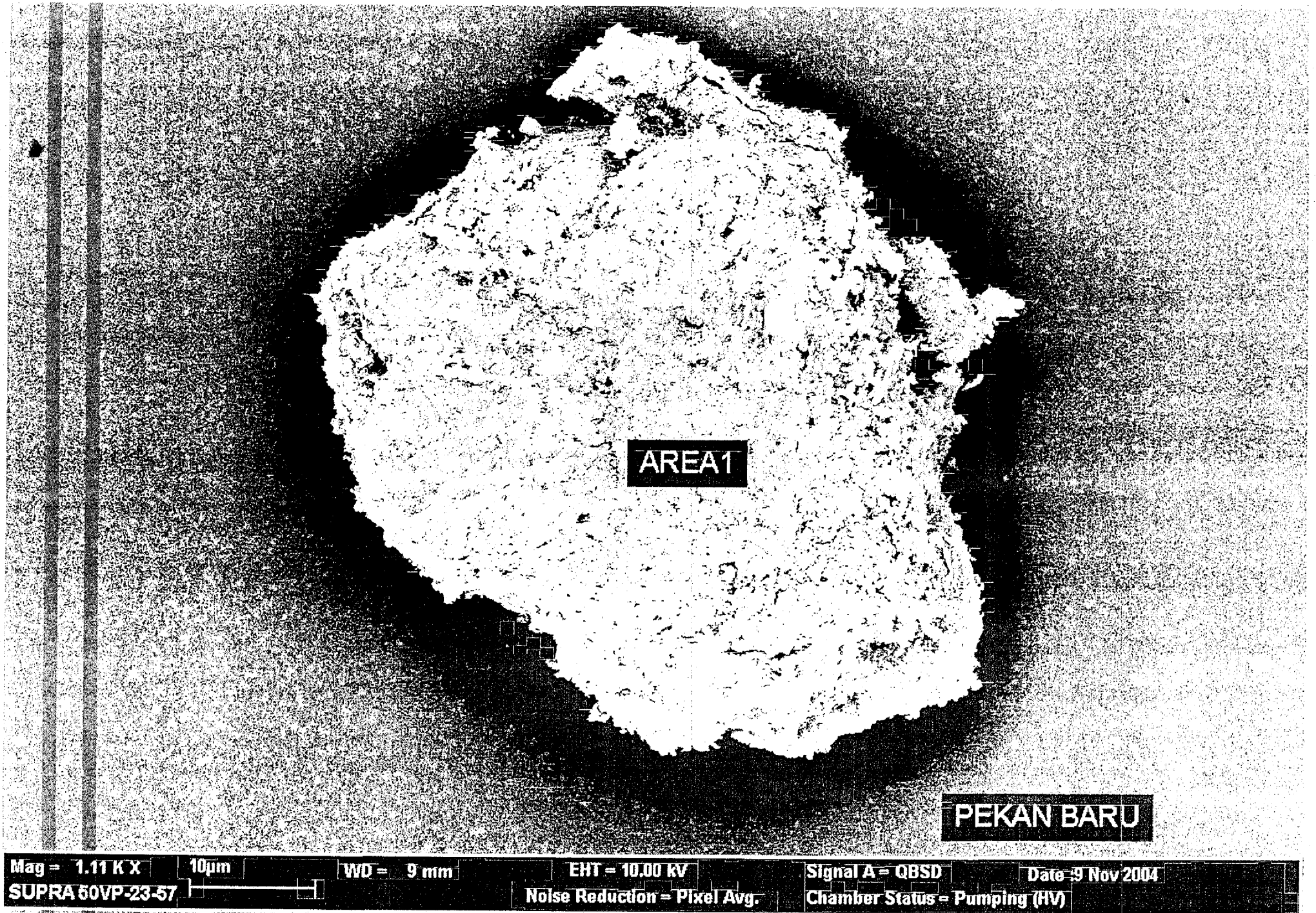

AREA3
KILANG PADI
Mag = 317 X
20µm
WD = 9 mm
EHT = 10.00 kV
Signal A = QBSD
Date :9 Nov 2004
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)


AREA1
KILANG PADI
Mag = 308 X
10µm
WD = 9 mm
EHT = 10.00 kV
Signal A = QBSD
Date :9 Nov 2004
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)


AREA2
KILANG PADI
Mag = 554 X
10µm
WD = 9 mm
EHT = 10.00 kV
Signal A = QBSD
Date :9 Nov 2004
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)


AREA1
AREA2
PUSAT BANDAR
Mag = 788 X 10µm
SUPRA 50VP-23-57
WD = 9 mm
EHT = 10.00 kV
Noise Reduction = Pixel Avg.
Signal A = QBSD
Chamber Status = Pumping (HV)
Date :9 Nov 2004


AREA3
PUSAT BANDAR
Mag = 1.52 K X
10µm
WD = 9 mm
EHT = 10.00 kV
Signal A = QBSD
Date :9 Nov 2004
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)


AREA1
PEKAN BARU
Mag = 1.11 K X
10µm
WD = 9 mm
EHT = 10.00 kV
Signal A = QBSD
Date :9 Nov 2004
SUPRA 50VP-23-57
Noise Reduction = Pixel Avg.
Chamber Status = Pumping (HV)