c/c

IN THE HIGH COURT OF DELHI NEW DELHI

W.P.(C) NO. 9901 OF 2009

IN THE MATTER OF:-

SUKHDEV VIHAR REIDENTS WELFARE ASSOCIATION & ORS. .....PETITIONERS

VERSUS

THE STATE OF NCT DELHI & ORS. .....DEFENDANTS

INDEX

NEW DELHI

DATED: 01.07.2010

(K.K.ROHATGI) & (KUNAL SINHA)
COUNSEL FOR PETITION
65, LAWYERS CHAMBER
SUPREME COURT,
NEW DELHI.

IN THE HIGH COURT OF DELHI NEW DELHI

WRIT ORIGINAL JURISDICTION

WRIT PETITION (CIVIL) No. 9901 OF 2009

IN THE MATTER OF

Sukhdev Vihar Residents Welfare Association & Ors Petitioners

Versus

The State of NCT of Delhi & Ors. Respondents

REJOINDER AFFIDAVIT OF THE PETITIONER TO THE COUNTER AFFIDAVIT OF RESPONDENT NO.3 - NDMC AND RESPONDENT NO.5 (DPCC)

I, S.C. SAREEN S/O SHRI G.C. SAREEN AGED ABOUT 67 YEARS R/O 108 SUKHDEV VIHAR NEW DELHI-110025 DO HEREBY SOLEMNLY AFFIRM AND DECLARE THAT :-

1. I am the President of the Petitioner No.1 Society and in that capacity dealing with the respondents and therefore well aware of the facts and circumstances of the case and therefore competent to file this affidavit.

2. I have read the counter affidavit of respondent no. 3, NDMC and understood its contents. All the averments in the counter affidavit are denied as incorrect and not maintainable save to the extent the same are consistent with the averments made or admitted herein under.

3. The location of the proposed plant is near Okhla STP, behind Sukhdev Vihar. The site plan of the location is ANNEXURE A-1.

4. I say that the land on which the MSW project is being planned to be installed was on lease by DDA to NDMC on the condition that "The land shall be used by NDMC for the construction of Compost Plant and for no other purpose whatsoever." Also, the other condition relevant to the issue was that "The land shall not be transferred to any other Deptt without prior permission of DDA obtained in writing." However, now the said land is purported to be transferred to a private party - New Delhi Waste Processing Company Pvt. Ltd. which is neither permissible under the lease nor under the law.

5. I say that the proposal of the location of Municipal waste processing plant at Sukhdev Vihar /Okhla is contrary to the Municipal Solid Waste (Management and Handling) Rules 2000. Rule 7(2) of the MSW is reproduced below:-

"1. ..

7. **Management of Municipal solid Wastes**

(2) The waste processing and disposal facilities to be set up by municipal authority on their own or through an operator of a facility shall meet the specifications and standards as specified in **Schedule III** and IV."

6. I say that the relevant clauses of Schedule III are reproduced below:-

"Specification of Landfill Sites

Site Selection

..

"

3. The land fill site shall be planned and designed with proper documentation of a phased construction plan as well as a closure plan.

4. *The land fill sites shall be selected to make use of nearby wastes processing facility. Otherwise, waste processing facility shall be planned as an integral part of the landfill site.*

8. The land fill site shall be away from habitation clusters, forest areas, water bodies, monuments, National Parks, Wetlands and places of important cultural, historical or religious interest.

9. A buffer zone of no-development shall be maintained around landfill site and shall be incorporated in the Town Planning Department's land use plans."

7. I say that as per the MSW Rules 2000, the land fill sites shall be selected to make use of nearby wastes processing facility and otherwise, waste processing facility shall be planned as an integral part of the landfill site. It is pertinent to note that there is no landfill site in the site in question i.e. behind Sukhdev Vihar. Thus any new selection of landfill site in that area will need to pass the rigours of MSW Rules 2000 which provides that the landfill site ought to be away from habitation clusters and a buffer zone of no-development shall be maintained around landfill site.

8. I say that otherwise the MSW Rules, 2000 provides that waste processing facility shall be planned as an integral part of the landfill site. Accordingly, the proposed MSW based waste to energy project meant for producing electricity through incineration has to be located as an integral part of a land fill site. As there is no landfill site at Sukhdev Vihar and therefore

the location of the MSW processing plant at Sukhdev Vihar violates the MSW Rules 2000 and therefore illegal. This is the position when even when there is no incineration involved, however, in the instant case, incineration is also involved and equity demands stricter observation of the MSW Rules, 2000. Therefore, surely this MEGA plant burning 2050 tons of MSW per day (SEVEN LAC FORTY EIGHT THOUSAND TWO HUNDRED AND FIFTY TONS PER YEAR) ought to be away from human clusters. It is submitted that this proposed MSW processing plant is only 100 meters away from Sukhdev Vihar DDA Flats, Haji Colony, Gaffer Manzil and close to other densely populated colonies like Sarita Vihar, Jasola Vihar , Ishwar Nagar etc and this project must be stopped.

9. I say that the compost plant, which by and large, remained non-functional for the last two decades, was set up in the said site in 1960s. As the compost plant by nature will not emit harmful gases, various colonies, with time, came into being around the said site, with valid approvals from various government departments. These include Sukhdev Vihar, Haji Colony, Gaffer Manzil, Jasola Vihar, Noor nagar, masih Garh, Johri Farms, Sarita Vihar etc. In fact Sarita Vihar and Sukhdev Vihar also have numerous DDA flats. Three of the most prominent hospitals are also very close to the said site, Apollo, Fortis Escorts and Holy Family. The nearest residential houses are only 100 meters away from the project site.

10. I say that it is evident from the minutes of the meetings as annexed by the Respondent no. 3, the distance of the habitual clusters or the existence of the buffer zone as prescribed in MSW Rules, 2000 were not even discussed in the meetings, which ought to have been the predominant concern of the various machineries of the state.

11. I say that even a lay man can see that the project is bound to create chaos in the already chaotic traffic situation in the Capital of India. At least 1300 tons of raw material (municipal solid waste) in 250 trucks (about more than 5 tons per truck) daily shall be transported from Timarpur and other location in Delhi through the Ring Road and Mathura Road to the location at Sukhdev Vihar / Okhla. Besides, another 225 tons of RDF in about 40 trucks (appx over 5.5 tons per truck) from Timarpur shall be transported to Sukhdev Vihar / Okhla. Also, catering to about 600 tons of ash to be evacuated from the site and also the return of all the trucks numbering about 300 the movement would bring the traffic on the Ring Road and Mathura Road in Delhi to a halt with the resultant consequences. Besides, the fugitive municipal solid waste and fly ash over the entire route would create its own problems and health hazards and hence, the project is fanciful, presumptuous and carried forward with non application of mind. As stated above three of the most prominent hospitals are also very close to the said site, Apollo, Fortis Escorts and Holy Family and as such due to the above said fact of increase in traffic on the main Mathura Road will create immense inconvenience for the patients visiting these Hospitals specially those who are due for emergency care and need immediate medical assistance.

12. I say that the respondents have been trying to confuse this Hon'ble Court by constantly indicating that the area behind Sukhdev Vihar is a landfill site and have been earmarked for waste disposal and management by whatever means they deem fit etc., which is denied by the Petitioner. Therefore, to comprehend the impact of the said project, it is necessary to

succinctly state the basic types of projects for waste management and disposal:

a) **Sewerage Treatment Plant (STP):** Sewage treatment is the process of removing contaminants from wastewater and household sewage. It includes *physical, chemical, and biological* processes to remove physical, chemical and biological contaminants. Its objective is to produce a waste stream (or treated effluent) and a solid waste or sludge suitable for discharge or reuse back into the environment.

Sludge produced by sewage treatment is *organic in nature* and contain useful amounts of plant nutrients such as nitrogen, phosphorus and essential trace elements. The most common treatment options include anaerobic digestion, aerobic digestion, and composting. However, sewage treatment plants do emit methane gas, which could create problem to respiratory system if exceeds the limits.

The present STP plant, unlike the proposed MSW plant, in the same area has not created any inconvenience or health hazards to the best of the Petitioners knowledge for the following reasons:

- it is a small plant,
- the distance from the habitual cluster is more than 100 meters
- the effect of the operation of the plant is localized
- sewerage system is underground
- very little use of chemical substance
- No burning of waste is involved.

b) **Composting**: "Composting" is a *biological process* and is widely accepted as a key component of integrated solid waste management. In this process, organic waste, such as food scraps and yard trimmings, is decomposed with microorganisms (mainly bacteria and fungi) to produce compost. Compost is organic material that can be used as a soil amendment or as a medium to grow plants.

Composting *does not involve burning of waste;* therefore, it does not release any toxic/hazardous emissions as in case of incineration. That the petitioner is also in the process of filing a separate independent writ petition challenging the operation of composting plant in the same area.

c) **Municipal Solid Waste Incinerators** (waste to energy projects): These projects involve burning and unlike the above two types are not organic in nature. Whatever control technology is used, all types of incineration result in releases of toxic substances in ashes and in the form of gases/particulate matter to air. These substances include heavy metals, numerous organic compounds, such as dioxin, furans, and gases, such as nitrogen oxides, sulphur oxides, hydrogen chloride, hydrogen fluoride, together with carbon dioxide. Pollutants that are emitted into atmosphere from an incinerator stack, as well as fugitive emissions, will dangerously affect local environment. Dioxin causes serious health problems including cancer, altered sexual development, reproductive problems, suppression of immune system, diabetes and hormonal effects.

d) **Landfilling:** According to the Municipal Solid Wastes (Management and Handling) Rules, 1999, 'landfilling' under rule 3 (xi) is defined as "disposal of residual solid wastes on land in a facility designed with protective measures against pollution of ground water, surface water and air fugitive dust, wind blown litter, bad odour, fire hazard, bird menace, pests or rodents, greenhouse gas emissions, slope instability and erosion."

13. I say that the site in question has a Compost Plant (which had remained non-functional for the last two decades) and an STP and that **there is no land fill site.** *Thus till now, the existent projects namely STP and Compost Plant, only involve physical, chemical and biological processes which are organic in nature; there is no incineration or burning of the wastes which is the chief bone of complaint of the petitioners in this petition as incineration in the proposed MSW Processing Plant, is inherently different from the processes adopted in composting or in STP and will produce many harmful emissions which is certain to affect the petitioners and many other colonies which are just 100 meters away.* Further, the Okhla Landfill site is adjoining ICD Railway Yard in Okhla Industrial Estate Phase-1, which is many kilometers away from the present site in question.

14. I say that this proposed MSW processing plant producing electricity by **BURNING** 2050 TONS of municipal solid waste per day (7.48 Lac tons per year) is in the midst of densely populated South Delhi colonies and is only 100 meters away from Sukhdev Vihar DDA Flats, Haji Colony, Gaffer Manzil and also very close to many other colonies including Jasola Vihar, Sarita Vihar, Ishwar Nagar etc. This incineration of municipal solid waste produces and releases a variety of toxic

discharges in the air, water and ground that are significant sources of a range of powerful pollutants well known for their adverse impact on health and environment and due to this project must be stopped.

15. I say that matter of Waste to Energy Projects had engaged the attention of the Hon'ble Supreme Court in the Writ Petition (C) No. 888 of 1996 titled Almitra H. Patel & Anr versus Union of India & Ors. and the Hon'ble Supreme Court vide its order dated 6-5-2005 was pleased to direct that till the position is clear , the Government would not sanction further subsidies. The Hon'ble Supreme Court also directed the Central Govt. to constitute a committee of experts and give its report. Copy of the Order of Supreme Court dated 6-5-2005 is placed as ANNEXURE - RJ-I.

16. I wish to further say that IA-18 in the Writ Petition (C) 888 of 1996 further came up for consideration of the Hon'ble Supreme Court on 16-5-2007 . The extracts of relevant conclusions of the expert committee as relied upon by the Hon'ble Supreme Court some of which as applicable to this case are reproduced :-

> *" In view of the problems of treatment and disposal of municipal wastes (solid and liquid) in our cities and towns , which are only likely to increase with the growth of population and urbanization , an integrated approach to waste processing and treatment will be necessary , as brought out in the MSW Rules , 2000. Therefore, instead of focusing on individual technologies, it would be desirable to take an integrated approach to the management and treatment of MSW, which would necessitate deployment of more than one technology in tandem."*
>
> *"The Committee has recommended that projects based on bio-methanation of MSW should be taken up only on segregation / uniform waste unless it is demonstrated that in Indian*

conditions, the waste segregation plant / process can separate waste suitable for bio-methanation. It has opined that there is a need to take up pilot projects that promote integrated systems for segregation / collection / transportation and processing and treatment of waste."

17. I say that the Hon'ble Supreme Court vide the order dated 16-5-2007 in IA 18 in W.P. (C) 888of 1996 directed that " In view of the report of the Committee and having regard to the relevant facts we modify the order passed by this court earlier and permit Ministry of Non conventional Energy Sources (MNES) to **go ahead for the time being with 5 pilot projects chosen by them** , keeping in view the recommendation made by the Expert Committee and then take appropriate decision in the matter." (highlighting and underlining added). Copy of the Order is already placed as Annexure- II at page 171 of the paper book.

18. I say that the word "Pilot" as per Oxford English dictionary when used as a verb means "test (a scheme, project etc.) before introducing it more widely". As per the free online dictionary (http://www.thefreedictionary.com), pilot project means "activity planned as a test trial."

19. I say that from the above it is evident that after the poor performance of Lucknow plant the Hon'ble Supreme vide its order dated 16-5-2007 had for the time being permitted to set up **five pilot projects only** basically **on trial basis** to validate the process and technology.

20. I say that the petitioner approached the Ministry of Non conventional Energy Sources (MNES) through Right to Information Act. The RTI application dated 15.10.2009 and the

reply by the Ministry of New and Renewable Energy dated 23.10.2009 had been annexed by the Petitioner in the Review Petition No. 448 in the instant writ petition as Annexure III and Annexure IV respectively. However, the questions framed by petitioner and their answer received are clubbed together and stated below for easy comprehension:-

Question No.1:- How many Pilot municipal solid waste based (MSW) " Waste to energy " projects have firmed up so far and would be coming up soon in the country?

Answer No.1:- Only one MSW based Waste to Energy project of 8MW capacity at Bangalore has so far been sanctioned for financial assistance under this Ministry's program for setting up of five MSW based projects .This project is expected to be completed by June 2010.

Question No. 2:- Name and location of pilot project as recommended by expert committee appointed by Hon'ble Supreme Court of India as per its order dated 16th May 2005?

Answer No. 2:- The Expert Committee constituted by this Ministry at the instance of Hon'ble Supreme Court did not recommend any location for Pilot Projects.

Question No.3:- Name the pilot projects and their location so far, if any identified by the MNRE as per the Hon'ble Supreme Court of India order dated 16th May 2007?

Answer No. 3:- As mentioned in para -1 above, the only project sanctioned so far under this Ministry's program for setting up of five pilot projects on MSW-to -Energy in accordance with order dated May 16, 2007 of Hon'ble Supreme Court of India, is 8 MW project in Bangalore. This

project is being implemented by M/s Sriniwas Gayathri Recovery Ltd., in public private partnership.

21. I say that from the above it is clear that the Municipal Solid Waste (MSW) Processing Complex near Sukhdev Vihar / Okhla New Delhi is NOT one of the pilot projects on MSW – energy in accordance with the order dated 16th May 2007 of the Hon'ble Supreme Court in IA 18 in WP(C) 888 of 1996 nor it is recommended by the expert committee appointed by the Hon'ble Supreme Court and the same was agreed to by this Hon'ble Court in its order dated 15-1-2010 in Review Petition No. 448 of 2009 in the instant WP (C) 9901/2009.

22. I further say that Municipal Solid Waste (MSW) Processing Complex near Sukhdev Vihar New Delhi shall process 2050 TONS per day of Municipal Solid Waste i.e. 7, 48,250:00 tons (SEVEN LAC FORTY EIGHT THOUSAND TWO HUNDRED AND FIFTY TONS ONLY) of Municipal Solid waste PER YEAR through incineration to produce 16 MW of power is a FULL scale project and cannot fall under the category of a pilot project as cleared by the Hon'ble Supreme Court vide its order dated 16-5-2007. Therefore, this FULL scale project at Sukhdev Vihar/ Okhla is contrary to the orders of the Hon'ble Supreme Court and must be stopped.

23. I wish to bring to the kind notice of this Hon'ble Court that despite the restriction by the Hon'ble Supreme Court vide its order dated 6-5-2005 this Full scale MSW project at Sukhdev Vihar / Okhla was approved in principle in the meeting held on 7-7-2006. (page 24 para 15 of counter-affidavit). MOU of the said project i.e. Municipal Solid Waste (MSW) Processing Complex near Sukhdev Vihar New Delhi was signed by respondent no.2 , MCD (admitted at para 5 (ii) of the counter

affidavit) and concession agreement also signed (Annexure - R-3/F of the counter affidavit at page 37 Sl. No. 3). MOU with Respondent No.3 as well as the land required is said to have been allotted to the private company for the project (letter dated 8-6-2006 of New Delhi waste Processing Company Pvt . Ltd- at page 12 of counter affidavit) and concession agreement approved by respondent no.3 NDMC (Annexure - R-3/F of the counter affidavit at page 37 Sl. No. 3).

24. I say that despite the restriction placed by the Hon'ble Supreme Court on such Full scale projects the environment clearance was given by the respondent no.6 - Central Pollution Control Board vide its letter No. 23-1/2006-IA -III dated 21-3-2007 and 9-5-2007 (pages 54 and 53 of the counter affidavit). Besides, respondent no. 5 , DPCC also gave its approval to this Full scale project as indicated in Annexure R-3/F of the counter at page 37 Sl. no. 5 (j) and also letter dated 9-3-2007 at page 41 of counter affidavit.

25. I say that the Hon'ble Court must take judicial notice that even when the Committee of experts appointed by Supreme Court were deliberating and trying to find out the best method of disposal of Municipal Solid Waste after the failures in Lucknow Plant etc from 6-5-2005 to 16-5-2007 the respondents, 1, 2,3, 5,6 and 8 were going full steam ahead to give their clearances and support for implementing this FULL scale project since 2005 when the land at the Sukhdev Vihar/ OKHLA site was handed over and MOU signed with Private parties.

26. I say that the project does not contemplate segregation of biodegradable and non-degradable waste at the inception. DPCC in their letter of authorization under MSW Rules, 2000,

dated 09/03/2007 to NDMC (which is annexed as Annexure R-5/4 to Reply affidavit of Respondent No. 5, DPCC), itself mentions at point 4 that the technology for processing of waste shall be in tune with DST TIFAC technology of mixed municipal waste to RDF/fluff preparation. Even if the respondents agree for segregation, I say that such complete segregation of wastes is practically impossible. Needless to say, if mixed waste is burnt, it will create problems of very toxic compounds such as dioxins and furans, heavy metals and other pollutants. Toxics are created at various stages of such thermal incineration technology, and not only at the end of the stack. These can be created during the process, in the stack pipes, as residues in ash, scrubber water and filters, and in air plumes which leave the stack. There are no safe ways of avoiding their production or destroying these once produced. In the present scenario, we may safely assume considering the practical difficulties, complete segregation is not practically possible. Therefore, in such a case, it is not advisable to make the residents guinea pigs for this project, whose technology is still under scanner and is being discussed. Thus, incineration of non-bio degradable wastes will lead to emission of very injurious gases in the surrounding atmosphere. Moreover, the whole project site will be dumped with tons and tons of wastes in the open, not only causing huge inconvenience to the nearby areas but also may lead to various diseases.

27. I say that the respondent has placed very high reliance on the fact that "integration of MSW and STP in the same complex would provide complete solution to waste problem of Delhi", however utterly fails to describe as to how will it solve the waste problem. The STP and waste to energy projects are inherently different in character. I further state that presence

of STP in the same facility where waste to energy project is located has No direct linkages with the proposed project.

28. I say that the respondents are trying to say that the RDF- the processed fuel from MSW is a clean and environmental friendly fuel which is incorrect. The waste to energy projects by incineration are classified under Kyoto Protocol as a source of greenhouse gas emissions (page 56 of the WP). The respondents are calling the electricity produced as 'green power" which is misleading and hides the facts on the deadly emissions out of incineration of **SEVEN LAC FORTY EIGHT THOUSAND TWO HUNDRED AND FIFTY TONS PER** YEAR of Municipal solid waste.

29. I say that the Municipal solid waste shall contain at least 5-6 % of plastic especially in the lax environment of working in the country and the same also find support in the opinion of two members of expert committee of Hon'ble Supreme Court. Such high contents of plastic produces deadly Dioxins and Furans and other dangerously poisonous compounds very injurious to health and environment.

30. I say that incinerators produce a variety of toxic discharges in the air, water and ground that are significant sources of a range of powerful pollutants well known for their adverse impact on health and environment. As per the United States Environment Protection Agency (USEPA) all municipal waste incinerators regardless of technologies release a number of pollutants, including cadmium, lead, mercury, dioxin, Sulphur dioxide, hydrogen chloride, nitrogen dioxide and particulate matter. Dioxin and mercury are of particular concern as they are toxic, persist in environment and bio-accumulates. It is also found that the burning of waste also

results in formation of hundreds of new more lethal compounds and there is no technology which could take out these pollutants.

31. I say that there is overwhelming scientific evidence that incineration is sure cause of ill health and several dangerous diseases like cancer. The communities like the petitioner's living in the immediate vicinity are at a greater risk from emissions, percolation etc. leading to diseases like cancer, nerve damage, delayed development, birth defects, brain damage respiratory and cardiovascular ailments etc. The womb offers little protection to the unborn child and these chemicals pass through and interfere with the hormone behavior during development of the child. Even breast fed infants would be affected as its byproducts contaminate even the mother's milk.

32. I say that 25-30 % of the mass that goes into an incinerator comes out as fly ash. Thus a total of approx. 600 TONS (about 100 trucks) of ash has to be removed every day from this 2050 TONS per day incineration project. This ash has high concentration of lead and/ cadmium. Fly ash is a mixture of fine particles with volatile metals and metal compounds, organic chemicals and acids condensed onto particle surfaces. It can also contain residue from reagents, such as lime and activated carbon, themselves with condensed or absorbed contaminants. Ash is thus toxic and the ash management at incineration facilities are of serious concerns for the safety of the workers and environment specially due to fugitive ash which escapes into the environment during handling, removing and transportation of the toxic ash.

33. I say that incineration of waste is neither sound for public health nor it is sound for the planet nor good economics. Relevant extracts of a pro bono presentation and important article by Paul Connet PhD is placed as ANNEXURE- RJ- II (colly). It is noted that simply by burning household trash we make the most toxic substances that we have ever been able to make in a chemical laboratory: polyhalogenated dibenzo para dioxin and furans called dioxins for short which cannot be fully removed. In addition this incineration releases many toxic metals form otherwise fairly stable matrices. At worst these metals go into the air at best they are captured in fly ash. Then there are the most dangerous particulates (nano particles) released in the air having grave adverse impact on health.

34. I say that the claimed benefits of MSW processing plant as enumerated in para 19 of the counter-affidavit and claimed status of being environment friendly are all presumptuous, incorrect and do not stand the scrutiny of scientific studies the world over. A copy of the study of Prof C. Vyvyan Howard M.B. ChB. PhD. FRCPath Jun 2009 only on the effect of particulate emissions on health emanating from waste to energy project is placed as ANNEXURE- RJ-III. In this study while elaborating the statement of Head of EU Waste Management it is high lighted that "The Commission does not support incineration. We do not consider this technique is favourable to the environment or that it is necessary to ensure a stable supply of waste for promoting combustion over the long term. Such a strategy would only slow innovation. We should be promoting preventing and recycling above all. Those countries who are in the process of drafting their planning should not base it upon incineration."

"Modern incinerators are a major source of fine particulate emissions"

" Not only do a high proportion of the UFPs(Ultra fine particulates) escape the filters , but they are chemically reactive and carry a wide range of products of incomplete combustion and absorbed metals with them. The subsequent direct uptake of these respirable particles and the ready transfer form the lungs into the blood stream may be part of the reason that traditional toxicology is at loss to explain the level of impacts for such apparently low exposures."

" Ultra find particles have been found to be chemically highly reactive even when originating from a relatively unreactive bulk material."

35. I say that the respondent no.3 and 5 are stating that they had given public notice in news papers Hindustan Times and Navbharat Times on 17-12-2006 and thus they had done their duty and still there was no representations from any resident welfare association or any Non Governmental Organization in the Public hearing. This public notice was during the time when the Committee of experts appointed by Supreme Court were deliberating and trying to find out the best method of disposal of Municipal Solid Waste after the failures in Lucknow Plant etc and is in clear violation of the directions of the Hon'ble Supreme courts directions.

36. I say that if one reads the public notice it does not show the magnitude and substance of the HAZARD the PUBLIC is likely to face in future due to proposed integrated municipal solid waste processing complex. The public notice reads *"Public Hearing for environmental clearance to the construction of proposed integrated municipal solid waste processing complex at Okhla – adjacent to existing STP Delhi."* I say that how a common man is to interpret the likely health and environmental hazards of an *"integrated municipal solid waste*

processing complex." There is not even a mention of 2050 TONS of municipal solid waste will be BURNT per day for producing electricity of 16 MW and the attended potential hazards. It is evident that the same have been deliberately suppressed to avoid opposition. Compared to this the Public Hearings of State/Central Electricity Regulatory Commissions as part of annual tariff revision exactly summarizes in terms of proposed tariff hike for various consumer categories and expected revenue gap. It is also submitted that why the information of public notice was not sent individually to resident welfare associations within one -two Km radius. Also, if there was NO public representation in the public hearing on a particular day then why there could not be a second public hearing?

37. I say that it has been held in M.C. Mehta v. Union of India, (2004) 6 SCC 588,

> "40. In Virender Gaur v. State of Haryana referring to Principle 1 of the Stockholm of the United Nations on Human Environment, 1972, this Court observed that right to have living atmosphere congenial to human existence is a right to life. The State has a duty in that behalf and to shed its extravagant unbridled sovereign power and to forge in its policy to maintain ecological balance and hygienic environment. Where in the zonal plan, a land is marked out and reserved for park or recreational purpose. Further, it was observed that though the Government has power to give directions, that power should be used only to effectuate and further goals of the approved scheme, zonal plans etc. and the land vested under the scheme or reserved under the plan would not be directed to be used for any other public purposes within the area envisaged thereunder. Dealing with the contention that two decades had passed, it was held that self-destructive argument to put a premium on inaction cannot be accepted."

38. I say that it has been held in Virender Gaur & Ors. v. State of Haryana & Ors. (1995) 2 SCC 577

> "7. .....The word 'environment' is of broad spectrum which brings within its ambit "hygienic atmosphere and ecological balance". It is, therefore, not only the duty of the State but also the duty of every citizen to maintain hygienic environment. The State, in particular has duty in that behalf and to shed its extravagant unbridled sovereign power and to forge in its policy to maintain ecological balance and hygienic environment. Article 21 protects right to life as a fundamental right. Enjoyment of life and its attainment including their right to life with human dignity encompasses within its ambit, the protection and preservation of environment, ecological balance free from pollution of air and water, santiation without which life cannot be enjoyed. Any contra acts or actions would cause environmental pollution. Environmental, ecological, air, water, pollution etc. should be regarded as amounting to violation of Article 21. Therefore, hygienic environment is an integral facet of right to healthy life and it would be impossible to live with human dignity without a humane and healthy environment. Environmental protection, therefore, has now become a matter of grave concern for human existence. Promoting environmental protection implies maintenance of the environment as a whole comprising the man-made and the natural environment. Therefore, there is a constitutional imperative on the State Government and the municipalities, not only to ensure and safeguard proper environment but also an imperative duty to take adequate measures to promote, protect and improve both the man-made and natural environment."

39. Similarly it has been held in State of M.P v. Kedia Leather & Liqour, (2003) 7 SCC 389 that environment, ecological, air and water pollution amount to violation of the right to life assured by Article 21 of the constitution and hygienic environment is an integral facet of healthy life. Right to life with human dignity becomes illusory in the absence of humane and healthy environment.

40. I say that keeping the aforesaid facts in view and the potential health and environment dangers of the proposed FULL scale project of MSW processing plant at Okhla/ Sukhdev Vihar producing electricity by **BURNING** 2050 TONS of municipal solid waste per day (7.48 Lac tons per year) in the midst of densely-populated South Delhi colonies and being only 100 meters away from Sukhdev Vihar DDA Flats, Haji Colony, Gaffer Manzil and also very close to many other colonies including Jasola Vihar, Sarita Vihar, Ishwar Nagar etc. this MSW project must be stopped. Copy of Site Map of the area around the Proposed Waste-to-Energy Project is annexed as ANNEXURE RJ-IV with Photographs only.

DEPONENT

Verification

I, the above named deponent do hereby verify that the contents of para 1 to 40 of the above affidavit are true to my knowledge.

Verified at Delhi this 1st day of July 2010

DEPONENT

ANNEXURE - RJ-1

ITEM NO.43 COURT NO.3 SECTION PIL 22

SUPREME COURT OF INDIA

RECORD OF PROCEEDINGS

WRIT PETITION (CIVIL) NO.888 OF 1996

ALMITRA H. PATEL & ANR Petitioner(s)

VERSUS

U.O.I. & ORS. Respondent(s)

(With appln(s) for directions, intervention, interim Relief and office report)

With S.L.P. (C) No.22111 of 2003

(With prayer for interim relief and office report)

Date: 06/05/2005 These Petitions were called on for hearing today.

CORAM :

HON'BLE MR. JUSTICE Y.K. SABHARWAL

HON'BLE MR. JUSTICE P.P. NAOLEKAR

For Petitioner(s) Mr. Sanjiv Sen,Adv.

In WP 888/1996: Mr. Vivek Sharma,Adv.

Ms. Manik Karanjawala,Adv.

In SLP 22111/2003: Mr. S.U.K. Sagar,adv.

Ms. Bina Madhavan,Adv.

22-A

Mr. Susan Zachariah,Adv.

Mr. A. Venayagam,Adv.

for M/s. Lawyer'S Knit & Cos.,Advs.

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Mr. Hemant Sharma,Adv.

Mr. Rakesh Khatana,Adv.

Mr. Tara Chandra Sharma,Adv.

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UPON hearing counsel the Court made the following

ORDER

The petitioners in support of prayers made in Interlocutory Application No.14 of 2004, inter alia, seeking directions against the Central Government to forthwith stay the sanction of any further subsidy in respect of proposed and future Municipal Waste to Energy Projects and further direction to the Central Government to constitute an independent Non-Governmental Review Committee of Experts to inspect the functioning and record of the Lucknow and Hyderabad Plants and assess performance against initial expectation and projections as also to assess process viability through energy-balance, mass-balance and water-balance calculations has brought to our notice a News Item published by The Times of India on 21st December, 2004. The said News report states that 839 million Municipal Sold Waste Treatment Plant in Lucknow has been abandoned due to insufficient supply of organic waste by Lucknow Municipal Corporation [Corporation]. It also states that according to the Chief of the Corporation the plant has not been abandoned, rather the workers have gone on a lock-out. From that report, it does appear that the generation of electricity has dipped to a mere 0.3 M.W. to 0.5 M.W. When the plant was commissioned, the projection was that it would generate 5 M.W. of electricity using bio-degradable waste.

Under the aforesaid circumstances, we hope that till the position is clear, the Government would not sanction any further subsidies. Meanwhile, within two weeks, the Central Government shall constitute a Committee of Experts and include therein Non-Governmental Organisations as well, to inspect the functioning and record of the Lucknow plant and file a Report before this Court. The petitioners may suggest the names of Non-Governmental Organisations, which may be considered for being included in the Expert Committee, to Mr. A.D.N. Rao, learned counsel appearing for the Central Government. Due regard would be given to the suggestions made, while constituting the Committee. The Report along with affidavit on the aforesaid aspect shall be filedwithin eight weeks.

Mr. Rao seeks leave to place on record the Report of the Inter-ministerial Task Force. Let the same be filed within one week.

The writ petition and the special leave petition are adjourned.

[T.I. Rajput]
Court Master

[V.P. Tyagi]
Court Master

ANNEXURE - RJ-II

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Why incineration is a very bad idea in the Twenty First Century.
by Paul Connett, PhD

An introduction to myself. I taught environmental chemistry and toxicology at St. Lawrence University in Canton, NY. I reached the rank of full professor and retired in May 2006. Since 1985 I have researched the dangers of incineration (I have co-authored six papers on dioxin) and have vigorously promoted an alternative strategy consisting of intensive recycling, composting, reuse, repair and re-design "if we can't reuse it, recycle it or compost, industry shouldn't be making it." Today this approach is called the Zero Waste 2020 strategy. This effort has taken me to 49 states in the US, 7 provinces in Canada and 51 other countries. In all I have given over 3000 pro bono presentations, largely to community groups but occasionally some officials deign to listen. On January 12, 2010 I had the honor of giving a presentation "Zero Waste for Sustainability" to the Division for the Sustainable Development at the United Nations.

Sustainability.

I will begin here: after ending war, sustainability is the most crucial challenge our civilization has faced since the beginning of the industrial revolution. On a finite planet we cannot run a throwaway society indefinitely. We have to ape nature and recycle everything we possibly can. We would need four planets if everyone in the world consumed like Americans. We would need two planets if everyone consumed like Europeans. Meanwhile, both India and China, with their massive populations, are hell-bent on copying our "over-consuming" lifestyle. It was India's Mahatma Gandhi who many years ago said that "the world has enough for everyone's need, but not for everyone's greed." We in the North and the West need to set a better example. Something has to change and the best place to start is with waste. Everyone makes waste, and as such we are all part of living in a non-sustainable way. But if everyone took that first vital step of keeping their discarded materials separate then they could join the movement which would move the world in a sustainable direction.

Incineration is not sustainable.

Every time a community builds a trash incineration it sets back the real solutions by 25 years - the time it takes to pay back the massive investment involved. Every time you burn something you have to go back to the beginning of the linear society (extraction-manufacture-consumption-waste). After 25 years you are no closer to sustainability. All you are left with is a pile of ash of approximately one quarter of the mass of the trash that was burned. Promoters claim that incineration produces energy and fights global warming. This is utter nonsense. Three - four times more energy is saved by recycling the same materials as burned. One European company estimates that a combination of recycling and composting reduces global warming gases some 46 times more than incineration generating electricity (AEA, 2001).

The social costs of incineration are staggering especially in developing countries. The huge amount of money spent on incineration goes into complicated machinery (over half the capital cost is needed for air pollution control) and most of it leaves the country in the pockets of the multinational companies that build these monsters. With

the alternatives most of the money goes into creating local jobs and local businesses, thereby staying in the community and the country. In Brescia, Italy, they spent about $400,000,000 building an incinerator and have created just 80 full-time jobs. While Nova Scotia, a province of Canada, after rejecting an incinerator, has created over 3000 jobs in the handling of the discarded resources and in the industries using these secondary materials.

So incineration is neither sound for the planet nor for the local or national economies. However, because this matter is largely in the hands of engineers and engineering consultants the only issue that has dominated their discussion is "Is it safe?"

Is incineration safe?

This is an issue I have followed for 25 years. The issue that peaked my interest was the incredible fact that simply by burning household trash we make the most toxic substances that we have ever been able to make in a chemical laboratory: polyhalogenated dibenzo para dioxins and furans (PCDDs, PCDFs, PBDDs, PBDFs etc) called "dioxins" for short. There are literally thousands of these substances. There is no question that over 25 years the industry has got better at capturing these pollutants but we are still hostage as to how well the plants are designed and operated, monitored and the regulations enforced. In addition to this, incineration releases many toxic metals from otherwise fairly stable matrices. At worst these metals (lead, cadmium, mercury, chromium etc) go into the air, at best they are captured in the fly ash in the air pollution control devices (APC). But it is a truism to state that the better the APC the more toxic the ash becomes. Where is this ash going to go? In Germany and Switzerland the fly ash is put into nylon bags and deposited in salt mines. In Japan a number of the incinerators vitrify the ash, making it into a glass-like material, but that takes a huge amount of energy away from the system. Do you know where the ash is going in this proposal?

For every four tons of trash burned you get at least one ton of ash: 90% is called bottom ash (that is the ash collected under the furnace) and 10% is the very toxic fly ash.

The formidable issue of nanoparticles.

There is nothing new about nanoparticles, which are particle of less than one micron in diameter. They are produced in any high temperature combustion which includes vehicles, coal-fired power stations, industrial boilers etc. What is new is nanotechnology where these particles, which have very unusual properties, are being used in many commercial products from shaving cream to tennis rackets. This has raised the question of whether they have any negative health effects. That question has given rise to a new discipline called nanotoxicology. It turns out that these particles have exquisite biological properties which are very worrying. They are so tiny that they can cross the lung membrane and enter the bloodstream. Once there they can enter every tissue in the body including the brain. The problem with incineration is twofold: a) because every object in commerce is likely to end up in an incinerator any toxic element used in these products is likely to end up in the nanoparticles. The

nanoparticles from incinerators are the most dangerous of any common source. b) There are NO regulations in the world for the monitoring nanoparticles from incinerators. In most countries the particles regulated are 10 microns and above.In some countries they regulate particles at 2.5 microns. But neither standard comes closer to monitoring nanoparticles. We are flying blind on this crucial issue.

I have attached a very important paper on this issue from Dr. Vyvyan Howard from Northern Ireland. I know Vyvyan very well and he is one of the brightest people I have ever met. He co-authored a book on nanoparticles in 1999. The attached paper was delivered in 2009 in a hearing on an incinerator proposed for Ireland. It is the most up to date review of the issue of nanoparticles and incineration available. Before any new incinerator is built in India, or anywhere else for that matter, government officials (or the public) should force the project director to produce a scientific response to the key questions posed in this paper. If they cannot do so, then clearly building such a plant is taking a reckless gamble with the public's health. Moreover, if we return to the opening of this statement, such a gamble cannot be justified on either economic or environmental grounds, both local and global.

The alternatives are not pie-in-the-sky

Many communities in California, Canada, Italy, New Zealand, Spain and the UK have embarked on the zero waste strategy (not all call it that) and have achieved some with very rapid and impressive results. San Francisco (population 850,000) has reached 72% diversion from waste disposal. Their goal for 2010 is 75% diversion and their goal for 2020 is Zero Waste. Many other communities in California have also reached over 70% diversion. In Italy over 200 communities have done so. Novarra near Turin (pop. 100,000) reached 70% in just 18 months. Salerno, went for 18% to 82 % in one year. Villafranco d'Asti (population 35,000) has reached 85% diversion and the small town of Ursibil in Spain has reached 86%.

Zero Waste in India

India is uniquely placed to achieve even greater diversion rates. You have hundreds of thousands of "rag pickers" scavenging every last piece of glass and bottle top from your landfills. Instead of frittering away millions (maybe billions) of dollars building giant incinerators put that money into formalizing this sector: give them buildings, good working conditions, protective clothing, showers etc, and educate their kids. Form them into cooperatives so that they can continue to share in the profits of the recovered material (if this is not made clear they will probably fight such a change). What these people are doing is the most difficult task of all: looking after the residuals. More than anything else these people need our respect. Householders can look after the recyclables, compostables and reusables.

For more about the nuts and bolts about the zero waste approach see my webpage at www.AmericanHealthStudies.org. There you will find a series of videotapes I have shot on Zero Waste around the world and also an essay entitled Zero Waste for Sustainabiity.

Remember we have only got one planet and we must start behaving as if that was the case. I also forward the power point presentation I gave at the UN on Jan 12, 2010 if any one is interested.

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ANNEXURE - RJ-III

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An Bord Pleanála

Statement of Evidence

Particulate Emissions and Health

Proposed Ringaskiddy Waste-to-Energy Facility

Professor C. Vyvyan Howard MB. ChB. PhD. FRCPath.

June 2009

Professor C. Vyvyan Howard MB. ChB. PhD. FRCPath.

Vyvyan Howard is a medically qualified toxico-pathologist specialising in the problems associated with the action of toxic substances on the fetus and the infant. He is Professor of Bioimaging at the University of Ulster and has written a number of papers and book chapters and spoken in a variety of forums to draw attention to the threat posed by environmental pollutants to the developing fetus.

He is a Fellow of the Royal College of Pathologists, Past President of the Royal Microscopical Society, Member of the British Society of Toxico-Pathologists, Immediate Past President of the International Society of Doctors for the Environment and Member of the European Teratology Society. He has just completed 6 years as a toxicologist on the UK Government DEFRA Advisory Committee on Pesticides.

A large part of Professor Howard's current research is the investigation of the fate toxicology of nanoparticles. His research team is in receipt of two large EU grants; 'NanoInteract and 'NeuroNano'. He has co-edited a book entitled 'Particulate Matter: Properties and Effects upon Health' published in September 1999 [1].

Vyvyan Howard has sat on two EU expert groups considering the threats and benefits posed by nanotechnology and recently addressed the House of Lords Select Committee on Science and Technology investigating the use of nanotechnology in food.

1 Summary:

1.1 Incineration and Health:

Scientific knowledge regarding the effects of solid waste incineration facilities on the health of a population living nearby is constantly being updated.

Adverse health impacts arising from both inhalation of combustion products and from contaminated food from older incineration plants, generally those operating during the 1970's through to the 1990's, are reasonably well described in the epidemiological literature. The main health endpoints studied have tended to relate to

1. respiratory symptoms and illness
2. reproductive effects, especially congenital anomalies
3. cancer.

A practical issue, and one of significant policy importance, is that the majority of published epidemiological studies relate to these older plants. With the more recent European Union regulations [2] many older plants have closed, or been fitted with more stringent emission controls. While this is obviously desirable from a public health perspective, it does raise issues of the relevance of studies around older plants, to populations affected by more modern facilities. Proponents of new facilities tend to dismiss the older research as irrelevant. Opponents take a contrary view arguing, not unreasonably, that similar claims of safety were made in relation to those older facilities when they were operating; that the risk assessments relied upon to show new incinerators are safe would not, if applied to the older plants, reveal the levels of impacts reported in the literature thus indicating that the risk assessments do not validate in real-world situations; and that epidemiology, by it's nature, involves retrospective studies. Furthermore the modern incinerators tend to be much larger than those operated historically so that although the emissions concentrations have reduced the total mass of pollutant emissions may even increase.

The comprehensive review by the Health Research Board [3], commissioned by Department of Environment and Local Government, was obviously aware of these arguments and concluded that *"there is some evidence that incinerator emissions may be associated with respiratory morbidity"* and that *"acute and chronic respiratory symptoms are associated with incinerator emissions"*.

The review also confirmed that "a *number of well-designed studies have reported associations between developing certain cancers and living close to incinerator sites. Specific cancers identified include primary liver cancer, laryngeal cancer, soft-tissue sarcoma and lung cancer*".

The Health Research Board recognised the problems of isolating causation in real world epidemiology and commented that *"it is hard to separate the influences of other sources of pollutants, and other causes of cancer and, as a result, the evidence for a link between cancer and proximity to an incinerator is not conclusive"*. They suggested that this could be addressed by *"further research, using reliable estimates of exposure, over long periods of time, is required to determine whether living near landfill sites or incinerators increases the risk of developing cancer. Studies of specific environmental agents and specific cancers may prove more definitive in the future"*.

A more recent World Health Organisation ('WHO') report [4] similarly concludes by suggesting that *"Further insights on health effects of landfills and incinerators are likely to be gained only from studies that consider exposure pathways and biomarkers of exposure and effect, and compare waste-related exposures with those due to other sources of pollution."*

In that context this evidence reviews the possible health impacts associated with emissions from incinerators and a specifically the concerns associated with ultrafine particulates.

1.2 Air Pollution and Health:

The relationship between air pollution and mortality has been well known for many years. Two of the most notable pollution incidents confirming the effects of air pollution were firstly the tragic events of the Meuse Valley, Belgium, where in December 1930, in the small town of Engis 60 people died in the space of three days [5]. This disaster provided incontrovertible evidence that air pollution could kill and therefore it attracted considerable attention from the scientific community.

In a contemporary editorial in the British Medical Journal, Haldane [6] stated that "the possibility of a similar disaster happening in this country [the UK] is a matter of great public health interest". He thought that disaster had been avoided so far in London because the city emitted a lot of heat, which produced convection currents. He warned – though to no avail, against plans to build big electricity generating stations. The subsequent London pollution incident in December 1952 resulted in an increase in deaths that has been estimated to be of approximately 4,000 by Logan (1953) or 12,000 in a more recent retrospective study [7].

Despite these huge impacts, it has not been until the last decade did the scientific community focus in earnest on the potential health hazard of PM exposure [8].

1.3 Particulates and Health:

Epidemiological studies worldwide have consistently demonstrated links between ambient particulate matter exposure and adverse health outcomes, including increased rates of respiratory and cardiovascular illness, hospitalizations, and pre-mature mortality [9, 10]. Particles are usually defined by their size, e.g., PM10 and PM2.5, as the mass of particles with aerodynamic diameters less than 10 to 2.5 μm, respectively. Recently, however, interest has also focused on the fraction of ultrafine particles (UFP) with a diameter less than 0.1 μm, which are abundant in number but contribute little to the mass [11, 12]. The UFPs are only usually measured for research purposes and are effectively outside regulatory control. It is these emissions that are the main theme of this evidence.

Studies have shown that ultrafine particles are more toxic than larger particles [13-15]. Furthermore, individual particles have been shown to be capable of inducing inflammation and oxidative stress [15], suggesting that particle number concentrations, which are dominated by ultrafine particles, may be more indicative of some potential health impacts than particle mass concentrations. UFP are also important because of their high alveolar deposition fraction, large surface area, ability to induce inflammation, and potential to translocate into the blood circulation system. At a given mass, ultrafine particles (diameter < 0.1 μm) have 10^2 to 10^3 times more surface area than particles with diameters in the 0.1–2.5 μm range and approximately 10^5 times more surface area than coarse particles (2.5 μm < diameter < 10 μm) [16]. This surface area-to-mass effect may affect the relative toxicity of particles to respiratory systems, in combination with a higher deposition efficiency of ultra fines in the alveolar region (Hughes et al., 1998).

Estimates of the number of excess deaths on a global scale due to particle inhalation have been made, and they amount to about 2 million/year of which c.370,000 per year are within the EU. The health effects are not limited to lung injuries. They deaths also include

cardiovascular diseases and cancers [17]. It is interesting in the light of these impacts to consider that as recently as 1992 the Lancet editorial was claiming that *"environmental pollution is unlikely to result in gross excess mortality"* [18].

1.4 Ultrafine Particles and Incineration:

Although not such a high contributor to national PM inventories incinerators appear to be very important local sources of particulate contamination. Aboh [17] assessed the contribution of a modern incinerator in Sweden to local PM2.5 levels and concluded that between 17 % and 32% of the particulates arose from the incinerator. This contribution may seem to be large compared with the relatively small increased modelled by Indaver of 0.5 $\mu g/m^3$ compared with an assessed background level of c 7 $\mu g/m^3$. Indaver appears to ignore, however, the very significant contribution made to particulate burdens by SOx and, especially, NOx emissions.

1.5 The Precautionary Principle:

There remains significant uncertainty about the level of health impacts associated with ultrafine particulates and other emissions from incinerators.

The WHO [4] emphasises that *"priority needs for research include development and application of biomonitoring, both in human observational studies and in toxicological research, the use of pharmacokinetic models to assess the influence of factors such as metabolism and timing of exposures, and the analysis of all relevant environmental matrices, in order to evaluate chemical exposure pathways and to assess the exposure for specific subsets of the population"*.

I consider that the evidence of risk of harm to human health and the environment is sufficiently high that a precautionary approach should be taken towards the permitting of new incineration capacity at least until there is much better information from the biomarker studies recommended by the WHO [4] and the Health Research Board [3].

Whilst I believe that it is sufficiently compelling in itself the uncertainties associated with the health evidence are supported by strong policy arguments in areas beyond the scope of this evidence. The 2007 WHO report [4] says *"the evidence of adverse health effects related to landfills and incinerators, although not conclusive, adds to other environmental concerns in directing waste management strategic choices towards reduction of waste production, re-use and recycling schemes, as prescribed by EU Directives"*. I note that the Health Research Board review [3] includes similar commentary and says that one submission *"included a letter from the EU Environment Commissioner, which stressed that 'incinerators are not the answer to waste management .... Incinerators only reduce the volume of waste but the environmental impact of incineration is significant.'"*

The same contributor quoted the Head of EU Waste Management, who stated that incinerators need enormous input in order to be economic and that in many countries they are now considered similar to nuclear power stations and should be avoided:

'The Commission does not support incineration. We do not consider this technique is favourable to the environment or that it is necessary to ensure a stable supply of waste for promoting combustion over the long term. Such a strategy would only slow innovation. We should be promoting prevention and recycling above all. Those countries who are in the process of drafting their planning should not base it upon incineration.'

2 Properties of particulates

2.1 Particle Size

In 1979, the U.S. National Research Council said [19] that measuring particles by weight, without regard to particle size, has "*little utility for judging effects*". Particle size is therefore a vital consideration when it comes to air pollution and health. The respirable fraction of particles found in air are classified into size bands which are generally defined as:

Coarse + fine	PM_{10}	The mass of particles per cubic metre which pass through a size-selective inlet with a 50% efficiency cut-off at 10 μm aerodynamic diameter
Fine	$PM_{2.5}$	As for PM_{10} but with a 2.5 μm cut-off.
Ultrafine = UFP or 'nanoparticles'	$PM_{0.1}$	As for PM_{10} but with a 100 nm cut-off, i.e. up to 0.1 μm diameter

It is helpful to compare the size of the particles with common material like fine beach sand and human hair [20]:

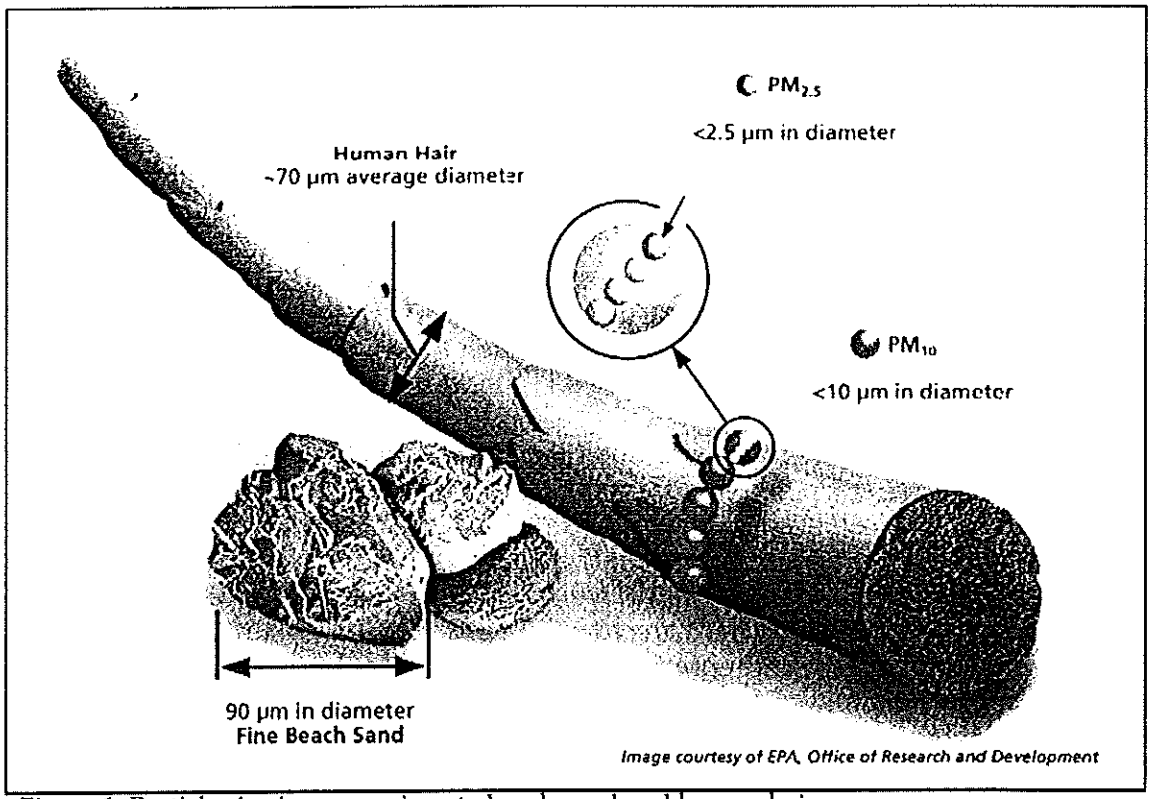

Figure 1: Particle size in comparison to beach sand and human hair

This relative size can also be illustrated by comparison to biological phenomena as per Brook et al. [21]:

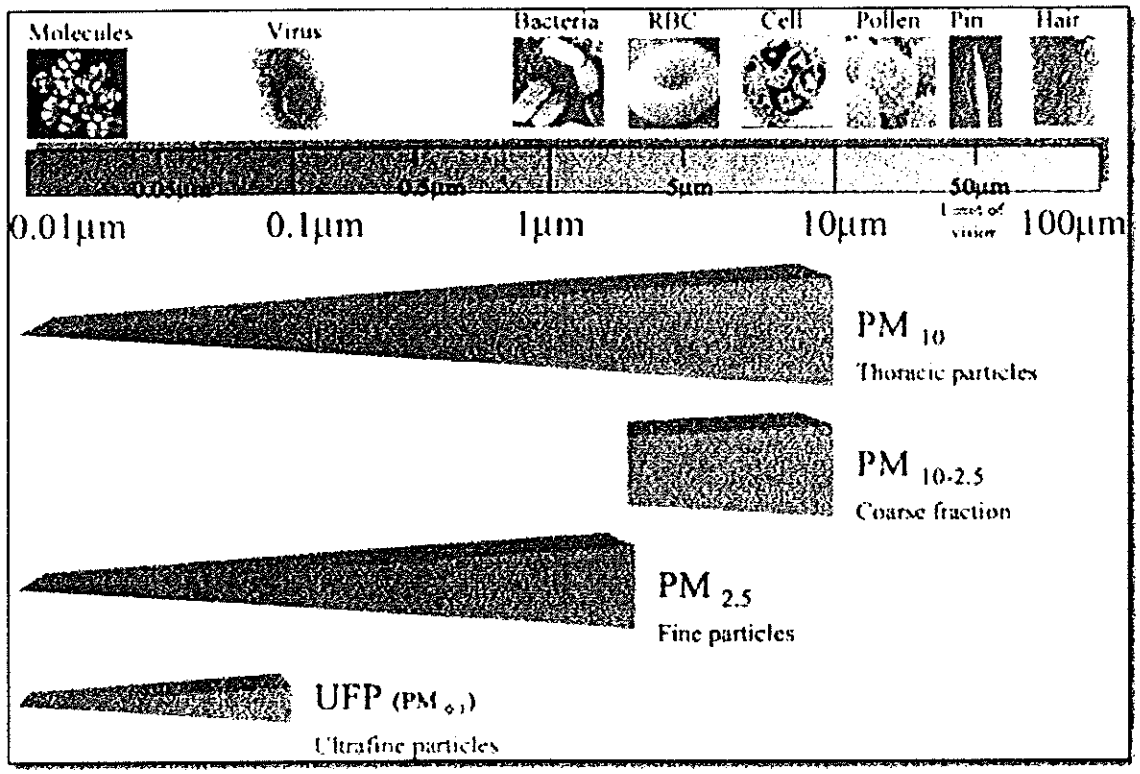

Figure 2: Particle size in comparison to common natural phenomena

The "coarse" particle mode is the difference between PM_{10} and $PM_{2.5}$. It is variable because it includes wind-blown dust and some contribution from building operations; as a 'rule of thumb' $PM_{2.5}$ is normally between 50% and 80% of PM_{10}. [22]

The figure below summarizes what is known about particle size distribution and how size distribution is connected to more common measures of particle number and mass. The percentage values were based on 1995–1998 data from Erfurt [23] and it can be seen that whilst c 97% of the particle mass is found in the components > $PM_{0.1}$ this constitutes only 12% of the particle numbers (note that this is based on total $PM_{2.5}$ levels being 100% of the mass).

	Contribution[a]	
Size (µm)	Number	Mass
Ultrafine particles		
$NC_{0.01-0.03}$ $NC_{0.03-0.05}$ $NC_{0.05-0.1}$	88%	3%
Fine particles		
$MC_{0.1-0.5}$ $MC_{0.5-1.0}$ $MC_{1.0-2.5}$	12%	97%
Total ultrafine and fine particles		
0.01–2.5	100%	100%
Coarse particles		
$PM_{10-2.5}$	—	20%
$TSP-PM_{10}$	—	30%

[a] Based on the data from Erfurt 1995 to 1998: contribution of ultrafine and fine particles to number and mass in the size range of 0.01–2.5 µm and contribution of coarse particles to mass of total aerosol size distribution.

Size Ranges and Contribution to Number and Mass Concentration [23]

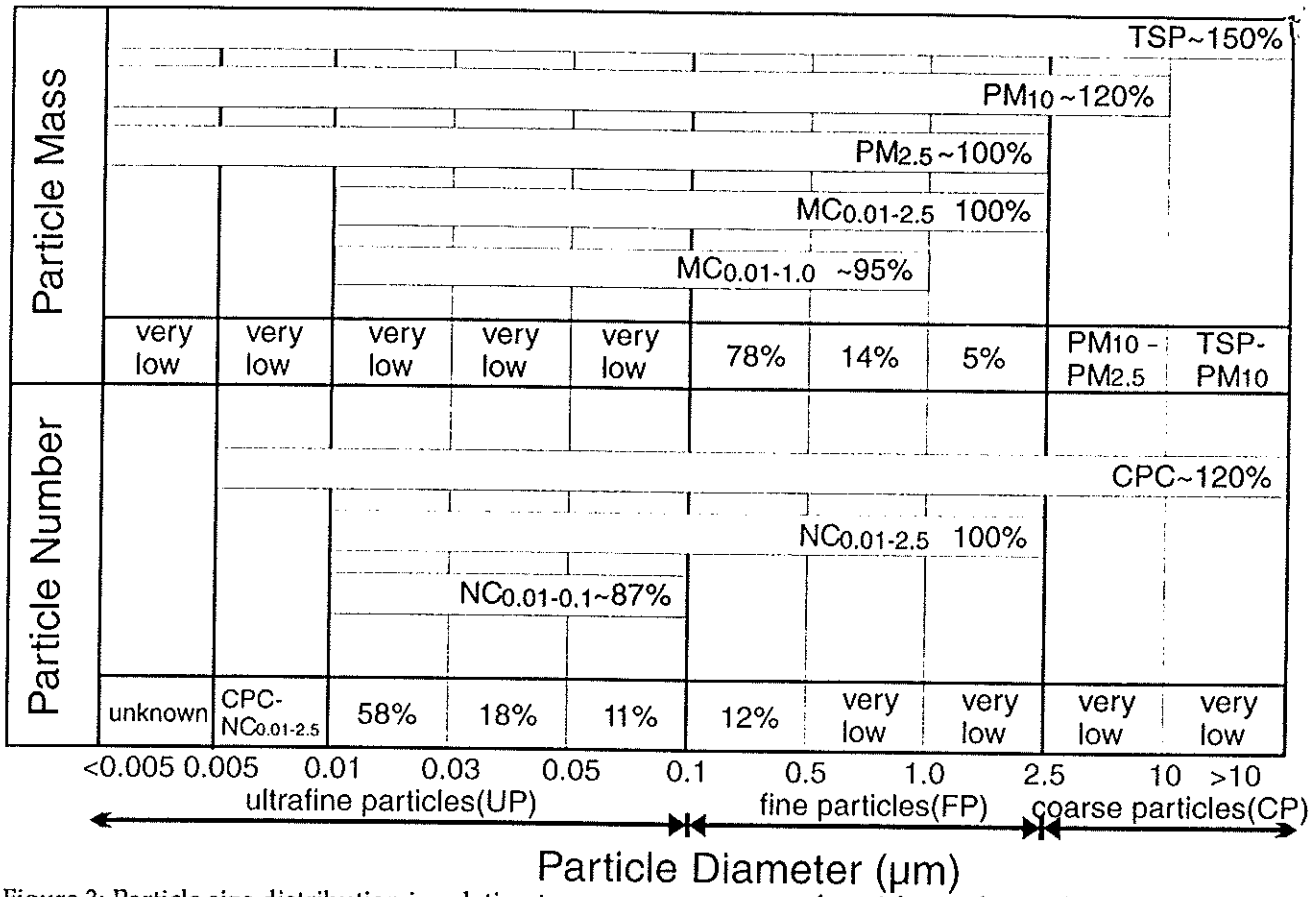

Figure 3: Particle size distribution in relation to common measures of particle number and particle mass

It is clear, therefore, that depending on their sizes, quite substantial differences in numbers or surfaces might constitute the same mass. Just one particle per cm^3 with a diameter of 2.5 μm is sufficient to result in a mass concentration of 10 $\mu g/m^3$ whilst more than two million particles of a diameter of 0.02 μm are needed to obtain the same mass concentration.

During the past 20 years, studies have largely been able to rule out sulphur dioxide and ozone pollution as the cause of the observed deaths although ozone is associated with increased mortality in daily time series studies (0.3–6.7% increase per 20 $\mu g/m^3$) and there is a weak association between SO2 and mortality (about 1% increase per 50 $\mu g/m^3$) which can be difficult to separate from particulate co-pollutants [24].

2.2 Ultrafine particles

Ultrafine particles (UFP) or nanoparticles[1], are very small pieces of matter defined as having dimensions less than 10^{-7} m. They constitute a small proportion of the mass of almost all types of particulate material. They also constitute the majority of the number of particles found in aerosols produced as a result of combustion processes. Their importance in the field of catalyst manufacturing, where their high surface area has a very great influence on reactivity, is widely known [25]. However, at present we know relatively little about their detailed structure, or their chemical and physical properties.

[1] Nanoparticles are smaller than 100nm, but in this evidence I take the terms to be interchangeable.

2.3 History and Regulation:

Regulation in Ireland of particulates as an air pollutant has been based on PM_{10} (particles of <10 μm) and, more recently on $PM_{2.5}$ – although not, so far as I am aware for setting emission standards from processes like incinerators.

In common with many leading researchers in this developing field of nano-toxicology such as Donaldson's [26] and Oberdörster's [27] groups, I have long considered ultrafine particles to be the main contributor to its adverse effects. Though UFP is only a small fraction of PM_{10} , Seaton et al. in 1995 [28] hypothesised biochemical processes whereby it might be the cause of acute cardiovascular effects. The 1999 Royal Society conference "Ultrafine particles in the atmosphere" and proceedings, published in 2000, consolidated the new thinking.

Urban air will often contain 100 billion (10^{11}) one-nanometre-diameter particles in each cubic meter of air, all of them invisible. By weight, these 100 billion particles will only amount to 0.00005 micrograms yet they may be responsible for much of the health damage created by fine-particle pollution. It is clear, therefore, that achievement of a regulatory standard does not ensure protection of health.

2.4 Lack of Standards and Monitoring for UFPs

Standards and monitoring are now being introduced for $PM_{2.5}$ particles – termed 'fine particles' and mostly 1,000 to 2,500nm in size – but there is nothing yet to cover the much smaller ones. The current standards are in terms of total mass, yet UFPs are generally around only one percent of the total mass but present the majority of the surface area that is reactive to human tissues. If the mass of a single inhaled 2.5 μm particle is divided into typical nanoparticles ~80nm, they would have 1000 times more surface area. For that reason alone, the mass-based PM standards are far from appropriate for UFPs.

Wichmann [23] reported some of the earliest epidemiology relating to UFPs and they showed a full distribution over particle sizes in urban air:

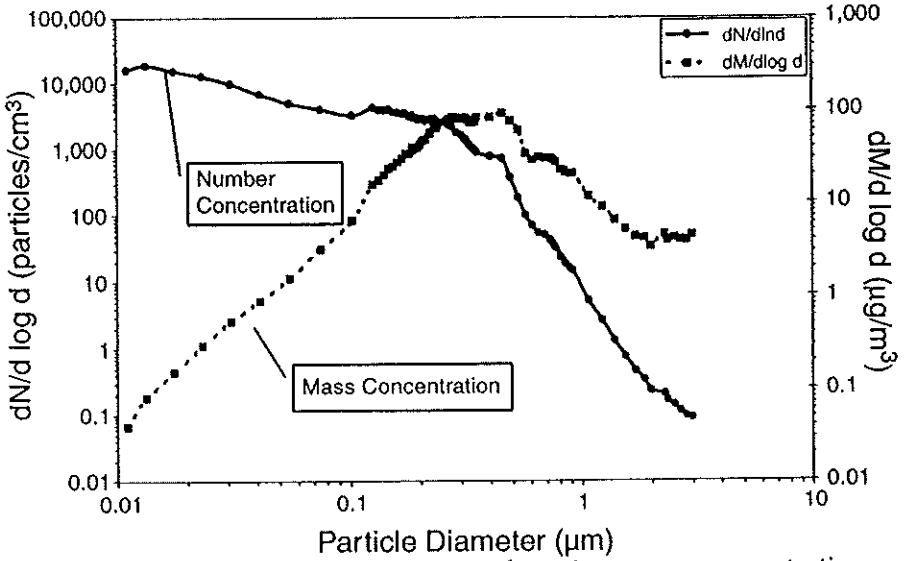

Figure 4: Particle size distribution in urban air mass vs. concentration

This does not show PM10 (cuts off at 3μm) but does indicate that most of the mass is in 0.2 to 0.5 μm particles, yet most of the particles ('number concentration') are under 0.2 μm (i.e. 200 nm).

2.5 Atomic Structure of Nanoparticles

It is only in the last twenty-five years, with the advent of high-resolution electron microscopy (HREM) at 0.1 nm (nanometre) levels, and the consequent ability to resolve inter-atomic spacings at this level, that any real attempt has been made to determine the atomic structure of ***individual*** particles. What has been learned is that these minute particles have an increasing proportion of surface atoms as the particle size decreases. Novel configurations of atoms have been demonstrated in nanoparticles, which cannot exist in the bulk material (Jefferson & Tilley, 1999). The imbalances between the number of atoms and number of electrons means the particles can be electrically charged and have raised chemical reactivity.

3 Damage to Health from Particulates

3.1 Fine Particles Linked to Human Deaths

US studies from the 90s first established that urban particulates in modern times were causing people to die. The 6-cities study of 1993 (Dockery et al.) was followed by the ACS study of half a million adult Americans in 151 metropolitan areas, which clearly established the relationship between fine-particle air pollution and human deaths, ruling out smoking as a cause of the observed deaths (Pope *et al.* 1995, Villeneuve *et al.* 2002, Pope *et al* 2002). This study is particularly important because it didn't simply match death certificates with pollution levels; it actually examined the characteristics (race, gender, weight and height) and lifestyle habits of all 552,138 people. Thus the study was able to rule out confounding factors of tobacco smoking (cigarettes, pipe and cigar); exposure to passive smoke; occupational exposure to fine particles; body mass index (relating to a person's weight and height); and alcohol use.

This study also controlled for changes in outdoor temperature. It found that fine-particle pollution was related to a 15% to 17% difference in death rates between the least polluted cities and the most-polluted cities. This research was vehemently attacked from a number of quarters, particularly those industries potentially most affected by the findings, which labelled it 'junk science'. However, an independent scientific panel conducted a thorough 're-analysis' and confirmed that tiny soot particles can shorten lives (HEI 2000). This basic finding was supported by a European study that found 6% of all deaths correlate with urban concentrations of fine particles, mainly from traffic [29].

The review of air pollution under the European Commission (Clean Air for Europe: CAFÉ) assisted by the WHO led to the Commission declaring in the *Thematic Strategy on Air Quality* that *"serious air pollution impacts persist"* [30].

The Commission also said *"currently in the EU there is a loss in statistical life expectancy of over 8 months due to $PM_{2.5}$ in air, equivalent to 3.6 million life years lost annually"*. The thematic strategy shows that even with effective implementation of current policies this will reduce only to around 5.5 months (equivalent to 2.5 million life years lost or 272,000 premature deaths).

3.2 Effects of Particle Types and Mixtures

The effect of mixtures of particles of differing chemical composition entering the blood stream via the lungs in large numbers on a daily basis is beginning to be understood. There is no doubt that some particulate aerosols are indeed hazardous. However the degree of hazard associated with specific types of particle and the precise mechanisms by which exposure leads to pathology are as yet poorly understood and currently the subject of increasingly intense research.

Boekelheide [31] reported that pregnant rat dams were exposed to mixtures of phthalates (suppressors of testosterone synthesis within the fetal testis) and androgen receptor antagonists (acting at the end organs of this signalling pathway). The exposures were orchestrated so that any agent alone had very limited effects while the collective exposure robustly induced hypospadias and epididymal agenesis in the developing males. Overall, the chemicals clearly acted with dose additivity, not response additivity. These effects were induced by chemicals acting by different molecular mechanisms within different organ

systems with different absorption, distribution, metabolism, excretion patterns, and differently shaped dose response curves. By all of our familiar criteria, these chemicals are not toxicologically similar and do not share a mode of action as defined by the USEPA; and yet they can act together to inhibit this developmentally sensitive signalling pathway.

3.3 Threshold Levels

Successive studies have concluded there is no threshold, i.e. no level of fine-particle pollution below which no deaths occur. The ACS researchers have found that even air pollution levels that are well within legal limits are killing people, especially older people and those with chronic heart and lung ailments.

3.4 Respiration of particulates:

The average human lung contains about 2,300 km of airways and 480 million alveoli [32, 33]. On a daily basis, humans inhale around 10,000 litres of ambient air, which comes in close contact with a lung surface area of between 75 and 140 m^2. From this, 350 litres of oxygen diffuses across the alveolar capillary basement membrane into the 10,000 litres of blood flowing through the lungs daily [34]. The respiratory tract, therefore, comes into close contact with a large volume of ambient air and its components on a daily basis – the potential for uptake of contamination contained within that air is obvious.

Whilst US researchers switched to correlating $PM_{2.5}$ with health indicators authorities in Europe have tended to remained entrenched with the concept of PM_{10}. There is, however, no longer and serious doubt that the size of the particles is the most important issue from a public health viewpoint and the reasons are obvious when the respiration of particles is considered in more detail.

- Particles larger than 10 μm (10 millionths of a metre) generally get caught in the nose and throat, never entering the lungs.
- Particles smaller than 10 μm (PM_{10}) can get into the large upper branches just below the throat where they are caught and removed (by coughing and spitting or by swallowing).
- Particles smaller than 5 μm (PM_5) can get into the bronchial tubes, at the top of the lungs.

Only particles smaller than 2.5μm ($PM_{2.5}$) in diameter can get down to the deepest (alveolar) portions of the lungs where gas exchange occurs between the air and the blood stream, oxygen moving in and carbon dioxide moving out [35]. The figure below shows whilst that PM $\geq$ 10μm in diameter enter the nose and mouth only the thoracic fraction, PM_{10}, passes the larynx and penetrates the trachea and bronchial regions of the lung, distributing mainly at pulmonary bifurcations. The respirable fraction, $PM_{2.5}$, and ultrafine PM, $PM_{0.1}$, enter the nonciliated alveolar regions and deposit deep within the lungs.

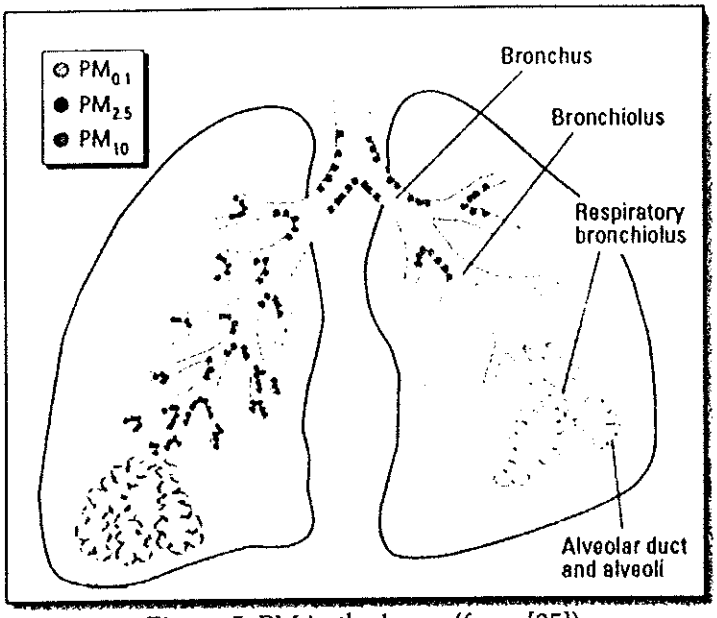

Figure 5: PM in the lungs (from [35])

Not all particles are retained. Larger particles deposit in the airways or mouth and throat, whereas smaller particles deposit in the alveolar region. A higher proportion of particles <1 μm that than those of $PM_{1.0}$ can be exhaled, thereby reducing deep lung deposition:

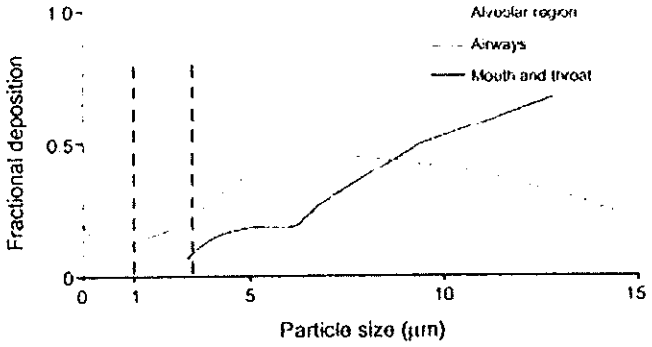

Figure 6: The effect of particle size on the deposition of aerosol particles in the human respiratory tract following a slow inhalation and a 5 s breath hold (from [33])

3.5 Fate of particulates deposited in the lung

Removal of the smaller particles (<2.5 μm) deposited in the alveoli is difficult. If soluble in water, they pass directly into the blood stream within minutes. If insoluble, they are collected by scavenging cells called macrophages, which transport them to lymph nodes where they are retained for months or years (NRC, 1979). However, lung macrophage cells seem to have difficulty in recognising the smaller UFPs (those <65 nm; Donaldson et al. 1999), so may let some of them through the lung epithelium, especially during episodes of high numbers. Once they penetrate the epithelium and enter the blood stream, UFPs may be transported around the body and potentially be absorbed into cells – a process called endocytosis. Gumbleton [36], and more recently, Yang [33] have reviewed nanoparticle mobility and removal mechanisms including endocytosis. UFPs can cross biological membranes, in common with many viruses, and their mobility within the body is thought to be high.

50

3.6 The mechanism of toxic action

I have summarised and discussed a number of mechanisms by which UFPs can induce cell damage in my 2009 nanoparticle review for the WHO. Unfortunately this is not yet in the public domain and cannot yet be supplied to this inquiry. I will, however, briefly review some of the key developments here.

In recent years it has been established that Ultrafine particles:

- have a high specific surface area, which can catalyse reactions and adsorb high amounts of toxic substances (like PAH), providing a carrier deep into the lung during inhalation [28];
- have a higher deposition probability particularly in small airways and the alveolar region of the lungs than fine particles [11];
- respond differently in men and women - Women receive a greater dose than men in the head and tracheobronchial regions, for example [37];
- are less well phagocytized by alveolar macrophages than larger particles and inhibit their phagocytic ability [38];
- are taken up by other cells of the respiratory epithelium, such as epithelial cells, dendritic cells [39, 40];
- may form complexes with proteins and biomolecules which may result in functional changes of the latter [41];
- have greater access to interstitial spaces than larger particles [42, 43]);
- have access to the blood circulation [43-45];
- induce more oxidative stress than fine particles [15, 46] ;
- cause more pro-inflammatory responses than larger particles [47] ;
- have greatly enhanced toxic potential due to their free location and movement within cells, which promote interactions with intracellular proteins and organelles and even the nuclear DNA [48] ;
- adversely affect cardiac functions and vascular homeostasis [49];
- affect the immune system [27].

For all of these hypotheses there exists a growing body of studies on a mechanistic level providing plausibility or evidence, however, on different levels of causality. From many of these studies it became also clear that the hypotheses listed above may only be applicable to susceptible organisms and individuals predisposed either by disease, genetics or age while the healthy organism does not show any such sensitive reactions.

A large number of studies confirm that fine-particle pollution is responsible for, or exacerbating, a wide range of human health problems, including:

- initiating and worsening asthma, especially in children;
- increasing hospital admissions for bronchitis, asthma and other respiratory diseases;

- increasing emergency hospital visits for respiratory diseases;
- reducing lung function (though modestly) in healthy people as well as (more seriously) in those with chronic diseases;
- increasing upper respiratory symptoms (runny or stuffy nose; sinusitis; sore throat; wet cough; head colds; hay fever; and burning or red eyes);
- increasing lower respiratory symptoms (wheezing; dry cough; phlegm; shortness of breath; and chest discomfort or pain); and
- increasing heart disease.

The 1995 hypothesis of Seaton *et al.* [28] suggested that the particles retained in the deep lung cause inflammation which, in turn, releases natural chemicals into the blood stream causing coagulation of the blood. This was to explain epidemiological findings of increased cardiovascular disease in populations exposed to higher than average PM_{10} exposure [50]. There may be a low exposure threshold, above which these effects will occur, but it appears the classical toxicological dose-response curve is not appropriate. The main end point under investigation is arterial damage, which is consistent with the 1965 findings of Aurerbach that smokers, who voluntarily inhale particulate aerosols, almost all sustain arterial damage themselves.

In vivo studies performed on laboratory animals have looked at the ability of UFPs to produce inflammation in lungs after exposure to UFP aerosols [26, 47, 51, 52] . The degree to which UFPs appear to be able to produce inflammation is related to the smallness of the particles, the 'age' of the aerosol and the level of previous exposure. It has been hypothesised [28] that the chronic inhalation of particles can set up a low grade inflammatory process that can damage the lining of the blood vessels, leading to arterial disease.

Most health studies are now using $PM_{2.5}$, though as runs of data in Europe tend to be of PM_{10}, uncertain corrections are often made. There are few data runs for ultrafine particles ($PM_{0.1}$), despite the finding [53] that they were on an increasing trend (while PM_{10} was decreasing) and probably more hazardous.

3.7 UFPs penetrating into the human body

There is considerable evidence to show that inhaled UFPs can gain access to the blood stream and are then distributed to other organs in the body [54].They can even cross the placental barrier.

One needs also to compare the particle sizes with biology, as in figure two above from Brook et al. [21]. UFPs are much smaller than bacteria, against which cells can defend themselves, and of similar size or smaller than viruses, which can relatively easily penetrate between cells.

The 'passageways' for nanoparticles into and then subsequently around the body are the 'caveolar' openings in the natural membranes which separate body compartments. These openings are between 40 and 100 nm in size and are thought to be involved in the transport of 'macromolecules' such as proteins, including on occasion viruses. They also happen to be about the right size for transporting UFPs. Most of the research on that, to date, has been performed by the pharmaceutical industry, which is interested in finding

ways of improving drug delivery to target organs. This is particularly so for the brain, which is protected by the 'blood brain barrier' which can be very restrictive. This has been reviewed by Gumbleton [36].

Although there are clear advantages to the intentional and controlled targeting of 'difficult' organs, such as the brain, with nanoparticles to increase drug delivery, the obverse of this particular coin needs to be considered. When environmental UFPs (such as from traffic pollution or incineration) gain unintentional entry to the body, it appears that there is a pre-existing mechanism which can deliver them to vital organs [36]. The body is then 'wide open' to any toxic effects that they can exert. The probable reason that we have not built up any defences is that any such environmental toxic UFPs were not part of the prehistoric environment in which we evolved and therefore there was no requirement to develop defensive mechanisms.

Peters et al. [55] having established the vulnerability of remote organs – and particularly the brain - wrote *"The results indicating that particles may contribute to the overall oxidative stress burden of the brain is particularly troublesome, as these long-term health effects may accumulate over decades"*. They stressed the need for increased efforts to quantify the relative risks for long-term particle exposure on the onset of Parkinson's and Alzheimer's disease adding *"both Parkinson's and Alzheimer's disease are only diagnosed once manifest clinical signs and symptoms are evident and impact the diseased persons by long years of disabilities and diminished quality of life"*. The exposure of the brain to UFPs is a matter of great concern - if our limited capacity to deal with misfolded protein is exceeded then the likely sequelae would be an increase in the incidence of protein misfolding disease in the general population and a tendency to an earlier average age onset.

3.8 Quantifying the Established Health Impacts

A range of impacts have been reported by different researchers for different outcomes. Kunzli [56], for example, reported elevations of 10 $\mu g/m^3$ and 20 $\mu g/m^3$ in $PM_{2.5}$ were associated with 5.9% and 12.1% increases in the development of atherosclerosis in *"healthy"* people who had no previous signs of acute coronary syndromes, but had small elevation of low-density lipoprotein.

Miller et al. reported an increased relative risk of 1.76 for death from cardiovascular disease for every increase of 10 μg per cubic meter in the mean concentration of $PM_{2.5}$ [57].

By comparison, a study by the American Cancer Society showed that each increase of 10 μg per cubic meter in the mean $PM_{2.5}$ concentration was associated with an increased relative risk of 1.12 for death from cardiovascular disease, 1.18 for death from ischemic heart disease (the largest proportion of deaths), and 1.13 for death from arrhythmia, heart failure, or cardiac arrest [58].

Commenting on these data in an editorial of the New England Journal of Medicine Dockery [59] wrote:

"A multifaceted approach that encompasses both public health and medical interventions is needed to reduce the burden of cardiovascular disease attributable to air pollution. Comprehensive management of the harmful effects of fine particles must start with intensive efforts to reduce this destructive form of air pollution. Fine particulate air pollution results not only from the combustion of carbonaceous fuels in our vehicles, power plants, and factories but also from secondary particles produced by oxidation of gaseous pollutants emitted by these same sources".

I note that these secondary particles have not been considered in the application at all and have not been incorporated in the (very limited) assessment of risks. It is clear however that even without the consideration of secondary particulates it is not reasonable to describe the particulate emissions from the proposed incinerators as having no impacts.

3.9 Children as vulnerable and sensitive sub-population:

The WHO and European Commission have recognised that children are specially affected by PM pollution. The WHO *Monograph: the Effects of Air Pollution on Children's health and development: a review of the evidence* [60] reviewed factors affecting children's susceptibility, effects on pregnancy outcomes, infant and childhood mortality, lung function development, asthma and allergies, neurobehavioural development and childhood cancer. It declared that *"the amount of ill-health attributable to air pollution among European children is high"*.

The *Children's Environment and Health Action Plan for Europe* (CEHAPE), adopted at the *Budapest Ministerial conference* in June 2004 [61], included air pollution in increasing concern about environmental effects on children's health. It agreed that developing organisms, especially during embryonic and foetal periods and early years of life, are often particularly susceptible. It's now recognised that the inhibition of children's lung development can be very serious, potentially meaning long term harm to their respiratory health. Evidently air pollutants, most probably including particulates, cause harm to children differently to adults.

The expert science view, summarised by Joel Schwartz [62] is that children's exposure to air pollution is of special concern because their immune system and lungs are not fully developed, so many of the epidemiological associations are likely to be causal. The review by Heinrich and Slama [63] found that ambient fine PM is associated with intra-uterine growth retardation, infant mortality; impaired lung function and postneonatal respiratory mortality, but less consistently with sudden infant death syndrome. Hertz-Picciotto et al. [64] found bronchitis in early childhood correlates with $PM_{2.5}$ and PAH levels (UFPs may be a carrier for PAH – see above). While these findings may not all be conclusive, there can be no doubt that children and even the fetus are particularly vulnerable to particulate air pollutants – while this has largely been overlooked in setting current standards and controls.

A review of health effects of poor air quality on children's health [65] emphasised the hazards associated with the siting of major particle-emitting plants and roads in the vicinity of schools or communities containing children.

3.10 Prenatal Exposure:

A 2007 Editorial [66] in the Journal "Reproductive Toxicology" summed up the increasing concerns associated with prenatal exposure admirably:

"There is a major paradigm shift taking place in science that while simple is profound. It states that the root of many diseases, including reproductive diseases and dysfunctions, will not be found by examination of disease onset or etiology hours, days, weeks, or even years prior to disease onset. The new paradigm suggests that susceptibility to disease is set in utero or neonatally as a result of the influences of nutrition and exposures to environmental stressors/toxicants. In utero nutrition and/or in utero or neonatal exposures to environmental toxicants alters susceptibility to disease later

in life as a result of their ability to affect the programming of tissue function that occurs during development. This concept, that is still a hypothesis undergoing scientific testing and scrutiny, is called the developmental basis of health and disease".

There is a growing recognition of the importance of the prenatal period as a "window of exposure" for the development of childhood, and possibly adulthood, disease [67]. Henderson et al. [68] have investigated the effects of mothers' exposure to household chemicals during pregnancy, but they acknowledged the difficulty in determining whether the reported health effects could be attributed to pre- or postnatal exposure, or even both. They observed that chemical use in the home before and after birth was highly correlated, making it difficult to separate potential effects of exposure during these periods.

Jedrychowski et al. [69] reported that prenatal exposure to $PM_{2.5}$ particulate matter had a moderate but significant impact on severity of respiratory illness in postnatal early life. The biological mechanisms whereby prenatal $PM_{2.5}$ exposure might cause adverse health outcomes in children are yet unclear. $PM_{2.5}$ is a proxy measure of a whole complex of toxic agents present in the environment – including PAHs – that could adversely affect growth and maturation of lung in early childhood.

Fine particles are usually a product of combustion processes that generate other toxic agents which may interact at the molecular level with DNA as described by Perera et al. [70]. Prenatal exposure to immunotoxic fine particles may impair the immune function of the fetus and subsequently may be responsible for an increased susceptibility of newborns and young infants to respiratory infections.

The synergism of recently proposed role of sulphur dioxide metabolites as inhibitors of enzymes and antioxidants and the adverse effects of nitrogen oxide metabolites in the early embryonic development may lead to symmetric intrauterine growth restriction and premature delivery or low birthweight. The research is directed to point out the toxics from coal combustion products as neglected causes of oxidative stress on human embryogenesis, prematurity, and low birthweight. [71]

3.11 Future Research:

Cormier et al [35] have reviewed the evidence for potential health impacts of particulate emissions from combustion processes. They posed a series of questions that require addressing:

- How are combustion-generated fine PM and ultrafine PM formed?
- How do their chemical properties differ from larger PM?
- What is the nature of association of chemicals with these particles?
- How is the chemical and biological reactivity of these chemicals changed by association with the particles?
- What is the role of PM-associated persistent free radicals in the environmental impacts of fine and ultrafine PM?
- What is the role of PM on cell/organ functioning at initial sites of exposure?
- What is the bioavailability of these particles to other tissues?
- How are these particles translocated to these secondary sites, and do their chemical properties change en route?
- How does acute/chronic exposure lead to adverse organ pathophysiology? Is developmental timing of exposure important?
- What effect does exposure have on predisposing to disease states or on disease progression?

- Most important, what are the specific cellular and molecular mechanisms associated with airborne exposures?

Medical science has been rather slow to fully recognize and explore the serious problems that particulate emissions cause. In spite of the thousands of papers that have been published over the past decade on the issue of UFPs it will inevitably be many years before the answers to all the questions posed are available. Meanwhile it is sensible that particulate emissions, especially those produced in conjunction with toxic chemicals, are reduced so far as possible and that new sources are avoided.

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4 Particulate Releases from Incinerators

Modern incinerators are a major source of fine particulate emissions. In 2007, for example, Widory et al. [72] found:

"The main sources of atmospheric particle pollution in Paris are vehicles, central heating and waste incinerators".

It is important to bear in mind that the contribution is not just direct PM emissions, which are now relatively low in terms of total mass and emission concentrations (though not in terms of numbers). Particulate emissions and impacts also include secondary inorganic compounds which can account for a major fraction of PM_{10}, and especially of the $PM_{2.5}$ mass [73]. Almeida [74] found lower but still significant contributions from these secondary particles.

As NO_x emissions from modern incinerators are still rather high (I understand that they normally operate close to the 200 mg/m^3 emission limit) then because of the increased size of modern plants compared with those operated in the early 1990's total levels are of the same order as historically – and the NO_x emissions can form nitrates with metals in the incinerator plume and thus increase the toxicity and availability of the emissions as described by Moffet [75]:

"The frequent observation of these metal-rich particles in an urban area with a high population density also has important implications for health effects. The largest fraction of the Pb-containing particles is less than 2.5 μm, meaning that these particles may be efficiently inhaled. Also, there may be important health ramifications if salts such as $Pb(NO_3)_2$ are formed because lead nitrate is soluble, and therefore more mobile within the human body".

Indaver appear to have completely omitted any consideration of secondary particulates and their impacts from their assessment.

Table 9.2 of the application shows that the proposed Ringaskiddy incinerators would produce 125,486 Nm^3/hr from the grate incinerator and 116,995 Nm^3/hr from the Fluidised bed incinerator i.e a total emission of 242,481 Nm^3/hr. The permitted particulate emission standard, subject to statistical limits, would be 10 mg/m^3 and for oxides of nitrogen 200 mg/m^3. Daily emissions could therefore total 5,819,544 m^3 containing 58.2 kg of particulates and 1,164 kg of NO_x.

These are large emissions in any terms – without any consideration of secondary particulates the authorised incinerator emissions would have the potential to daily fill a space 11km x 11km by 50 m deep to the WHO annual guideline of 10 $\mu g/m^3$ for $PM_{2.5}$.

Secondary particles should, of course, be considered in any case. The formation mechanism of nitrates as secondary particles is illustrated below [76]:

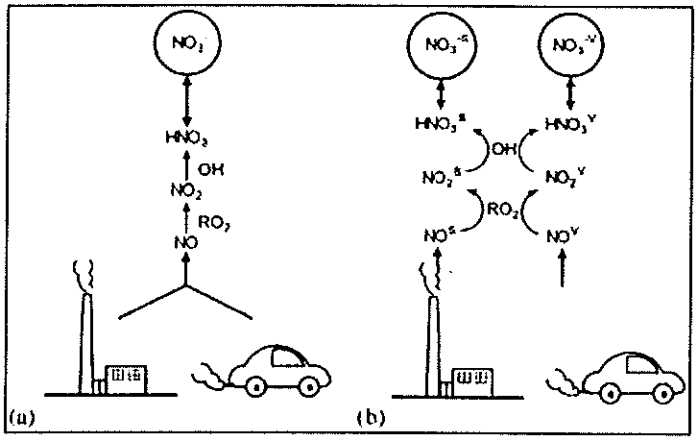

Figure 7: Illustration of source apportionment for secondary PM2.5 nitrate from two sources. (a) Formation of secondary PM2.5 nitrate in traditional air quality model using lumped NO emissions. (b) Formation of secondary PM2.5 nitrate from NO emitted from two sources tracked separately in the source-oriented air quality model used by Ying (from [76]). RO_2 represents a peroxy-type radical, and OH represents hydroxyl radical.

Furthermore emissions from an incinerator installed with a selective non-catalytic reduction (SNCR) NO_x control system as proposed here may actually increase direct emissions of ammonium nitrate which is an important component of $PM_{2.5}$

The efficiency of the filter is therefore not the most significant aspect of the total particulate emission and control of NOx (and to a lesser extent SOx is actually more significant in terms of the contribution to ground level concentrations although neither appear to have been modelled in this application.

4.1 Filter Efficiency:

The proposed incinerator would use a bag filter as the main primary particulate abatement technology. For a given fibrous filter, there is a particle size, usually between 0.05 and 0.5 μm that has the minimum collection efficiency [77] ; that is, all particles, larger or smaller than this size, are collected with greater efficiency. For a given size particle, there is also a velocity for minimum collection efficiency. It is important to establish where this minimum efficiency lies, what the particle density of the emissions at that point are and what the speciation of contaminants (both metals and products of incomplete combustion) carried by those particulates is.

Waste incinerators with the most modern bag filter technology for clean-up of flue gases still emit an aerosol of ultrafine particles, unlimited by legislation [78-81].

Collection efficiencies for particles < 2.5 μm are between 5 and 30% before the filters become coated with lime and activated carbon.

Particle size	Collection efficiency
PM10's	between 95% and 98%
PM 2.5's	between 65% and 70%
PM below 2.5	between 5% and 30%

Efficiency of baghouse filters for particles of differing sizes as claimed by operators. (Onyx 1999)

Though there have been improvements since 1999, the bag filter technology generally used on municipal waste incinerators is not efficient at filtering very fine particles. For particles of less than 1 μm down to about 0.2 μm the abatement efficiency is low. Although very high capture rates, based on gravimetric indices, are generally claimed, the majority by number of ultrafine particles will pass through and current standards do not take into consideration the sizes of the particles emitted by an incinerator. Thus modern plants with their very high gas fluxes are guaranteed to produce an ultrafine particulate aerosol.

Aboh [17] concluded that depending on the number of variables considered, waste incineration and local sources contributed between 17 and 32 percent of $PM_{2.5}$. Whilst the quantitative contribution from the different sources may be treated as indicative since the number of observations were small compared to the number of variables relative strength of the identified sources was seen to change when the variables included in the analysis were varied in number and character, although the same sources remained:

	Waste incineration and local sources	Oil incineration	Biomass burning	Long distance transport (LDT)	Traffic emissions
19 variables	32	33	18	16	1
14 variables	28	29	9	23	12
8 variables	17	21	7	41	14
6 variables	24	11	8	51	6

Ogulei [82] used applied multivariate data analysis methods to a combination of particle size and composition measurements in Baltimore to apportion particulate sources and found that the majority of all the observed Lead (63.4%) and most of the Zn (32.6%) could be attributed to a waste incinerator source. The closest major municipal incinerator to the monitoring site was c. 5 miles away in a direction corresponding to the direction suggested by their analysis. The contribution from this incinerator was about 7.9% which was comparable to the 9.3% contribution that was obtained in their earlier study [83]. The size distribution for this source indicated two modes at 0.02 and 0.15 mm. Whilst the incinerator made approximately the same contribution as both local petrol traffic (8.11%) and coal fired power station (10.34%) the particulate peak was smaller than each of the others and the concentration of heavy metals was much greater in the incinerator particulates.

Ultrafine particle concentrations have been shown to be raised in the plume of a hospital incinerator[3] 350 metres downwind of the plant [84].

4.2 Bimodal Size distribution

It has been known for many years that Aerosol emissions from combustion processes including waste incineration tend to show a bimodal mass distribution with a peak of coarse particles and another of ultrafines *[85, 86]*.

Friedlander [87] wrote:

The coarse mode consists of particles with diameters in the range between 1μm and about 100μm. In pulverized coal combustion they are formed from the nonburnable mineral inclusions within the fuel particles (Flagan and Friedlander, 1978). In addition to the large fly ash particles there often exists a

[3] The ratio of SO_2/NOx is greater than from vehicle emissions suggesting a fuel of higher sulphur content and discounting a gas fired boiler as an alternative source.

mode of small submicron sized particles which pose a health risk because they are inhalable and may be enriched in toxic metal compounds.

Friedlander pointed out, as we return to below, that the submicron particles are usually less efficiently captured by filter devices and hardly fall under gravity so remain longer in the air .

Ruokojarvi [88] found that half the particle mass in incinerator emissions was under 1.6μm, the remainder in a broad distribution up to 14.5μm.

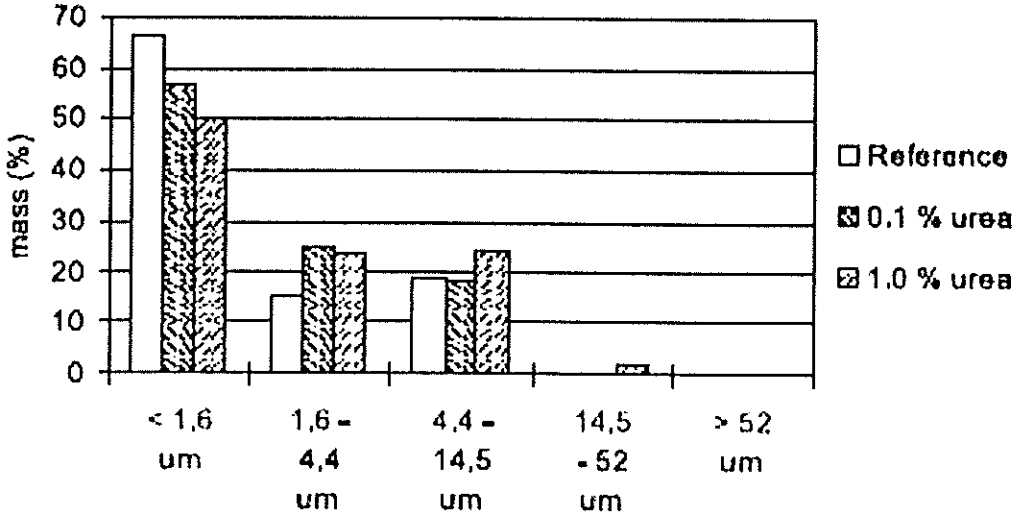

Fig. 4. Mass distribution of particles collected in the cascade centripeter samples.

This figure shows that half the mass is below 1.6μm, somewhat less than in the urban air of Wichmann [23] but it doesn't show the UFPs. Little information has been provided on particles under 1 μm size as the industry is uncomfortable over the issue. Some other data is given below.

4.3 Surface Area of incinerator particles:

The US EPA [89] characterisation of incinerator particulate emissions in the Table below showed that particles <0.7 μm have half the total surface area. Insofar as surface area in contact with lung's surface (epithelium cells) is relevant to exposure/dose effects, the smallest particles carry high weighting, unlike where the total mass (PM index) is considered.

Particle Diameter (μm)[a]	Particle Radius (μm)	Surface Area Volume	Fraction of Total Weight	Proportion Available Surface Area	Fraction of Total Surface Area
>15.0	7.50	0.400	0.128	0.0512	0.0149
12.5	6.25	0.480	0.105	0.0504	0.0146
8.1	4.05	0.741	0.104	0.0771	0.0224
5.5	2.75	1.091	0.073	0.0796	0.0231
3.6	1.80	1.667	0.103	0.1717	0.0499
2.0	1.00	3.000	0.105	0.3150	0.0915
1.1	0.55	5.455	0.082	0.4473	0.1290
0.7	0.40	7.500	0.076	0.5700	0.1656
<0.7	0.40	7.500	0.224	1.6800	0.4880

Total surface area: 3.4423 μm^2

Notes: a. Geometric mean diameter in a distribution. Distribution from EPA (1980).

Research has shown that even normally harmless bulk materials tend to become toxic when divided into ultrafine particles. Generally, the smaller the particles, the more reactive and toxic their effect [51, 52]. This is no surprise, because catalysts to enhance industrial chemical reactions are commonly made this way. Making surfaces that are irregular on the scale of just a few hundred atoms creates an enormous area of reactive surface. It is on this surface that catalytic reactions, such as the formation of halogenated organic molecules, can occur. Indeed, because of surface roughness, ash particles can have surface areas 20-30 times the surface area of equivalent spheres [90]. Some of the most reactive nanoparticles to have been studied to date are metals and spinel metal oxides [25]. The upper size limit for such enhanced toxicity of UFPs is not well defined but is generally given between 65 and 200 nm.

4.4 Speciation – inorganic components

Although the particles emitted from large-scale industrial combustion sources are all predominantly in the fine-particle range, their chemical compositions varies substantially depending largely upon fuel types and boiler or furnace operating conditions. This can be illustrated using the fractional abundances of the elements and chemical compounds in the particulate emissions[91].

Typical chemical abundances in source emissions

Source	Dominant particle size	Chemical abundance (mass fractions)			
		>10%	1–10%	0.1–1%	<0.1%
Coal-fired boiler	Fine	Si	SO_4^{2-}, OC, EC, S, Ca, Fe, Al	NH_4^+, P, K, Ti, V Ni, Zn, Sr, Ba, Pb	Cl, Cr, Mn, Ga, As, Se, Br, Rb, Zr
Incinerator	Fine	NH_4^+, Cl, SO_4^{2-}, OC	NO_3^-, Na, EC, Si, S, Ca, Fe, Br, Pb	K, Al, Ti, Zn, Hg	V, Mn, Cu, Ag, Sn
Residual oil boiler	Fine	S, SO_4^{2-}	Ni, OC, EC, V	NH_4^+, Na, Zn, Fe, Si	K, OC, Cl, Ti, Cr, Co, Ga, Se
Wood waste boiler	Fine	K	Na, Fe, Mn	Zn, Br, Cl, Rb	Cr, Cu, Co, Ni, Se, Cd, Ar, Cr, Pb

Key: OC = organic carbon, EC = elemental carbon.

This indicates incinerators are special for Pb, Hg and Br emissions (none of which come in particulates from vehicle emissions).

4.5 Particle Speciation:

Metal emissions from incineration of solid wastes are impacted by compositions of feedstocks and the chemical form of the metals depends on the operating conditions of the incinerator (Wey et al. [92]). A number of studies have identified the 'signature' of incinerators from the metal species. Harrison et al. reported on Birmingham air sampling in 1997 [93], finding zinc and copper to indicate an incineration source. They saw this as the large municipal refuse incinerator within the city (Tyseley), which at the time of sampling was not subject to the tighter Waste Incineration Directive limits.

In the city of Seoul, Mishra et al. [94] found via principal components analysis suggest incineration and the iron and steel industry as possibly significant sources of Pb in particulate matter. Doucet and Carignan [95] examined lead isotopes in French lichens and flyash from different municipal solid waste combustors in the Rhine valley and in other areas of France, concluding that *"these plants* (ie the incinerators) *might be an important source of industrial Pb in the atmosphere"*.

Pancras reported [96] *"Large but brief 1.5-h excursions in Zn, Cd, and Pb were found to correlate with winds from the direction of an incinerator in Florida at 17km distance"*.

4.6 Speciation – volatile and organic components

Out of over 11 million known chemicals, about 100,000 are being produced on industrial scale and about 1,000-2,000 new chemical entities are being introduced each year [97]. Any of these industrial chemicals may be disposed of by incineration and there is a near infinite number of possible combustion and incomplete combustion products that may be emitted either as particulate matter or by adsorbtion onto or reaction on the surface of particulates. Even if these emissions were monitored, and the vast majority are not, then little or nothing is known about the possible health impacts of the bulk of these emissions.

Volatile chemicals condense on particle surfaces as the incinerator exhaust gases cool. Their concentration on smaller particles is higher, being related to surface area rather than particle mass. This has been subject to particular studies for dioxin and dioxin-like chemicals, but is likely to be similar for many others e.g. [98]. It also holds for volatile chemicals that incinerator UFPs pick up from urban air, specifically the PAHs from vehicle emissions. These cannot penetrate into the body as gases, but if attached firmly to UFPs can be carried through the lung epithelium.

4.7 Range of chemicals coating the particles

There are thousands of chemicals emitted by incinerators. Jay and Stieglitz [99] identified 227 individual organic compounds[4] corresponding to ca. 42% of the total organic carbon

[4] Including: acetic acid, acetone, acetonitrile, aliphatic alcohol, aliphatic amide, aliphatic carbonyl, anthraquinone, benzaldehyde, benzene, benzoic acid, benzoic acid methyl ester, benzoic acid phenyl ester, benzonitrile, benzophenone, benzothiazole, benzyl alcohol, benzyl alcohol, benzylbutylphthalate, bibenzyl, bromochlorobenzene, bromochlorophenol, 2-bromo-4-chlorophenol, bromodichlorophenol, 4-bromo-2,5-dichlorophenol, butanoic acid ethyl ester, 2-butoxyethanol, butyl acetate, C10H20 HC, C10H22 HC (1), C10H22 HC (2), C11H15O2N aromatic, C12H26 HC, C12H26O alcohol, C13H28 HC, C15 acid phthalic ester, C4 alkylbenzene, C5 alkylbenzene, C6H10O2 aliphatic carbonyl, C6H12O, C8H14O cyclohexanone, derivative, C8H5BrCl3 aromatic, MW, 284, C8H5O2N, C9H18O3 aliphatic, C9H8O aromatic, caffeine,

(TOC) in flue gas from an incineration facility of MSW. The identifications exceeded ~50 ng/m^3, 500x higher than the dioxin emission limit set in the Waste Incineration Directive. About 3% of the TOC consisted of halogenated compounds, almost all of which were volatile compounds, while all of the identified semi- and nonvolatile halogenated compounds were aromatic compounds. Besides, 7% of the TOC was aromatic hydrocarbons and 3% of the TOC was phenols [100]. Highly carcinogenic compounds such as dibenzopyrene isomers have been identified and determined in Swedish incinerator emissions by other researchers [101] and it is likely that due to the very heterogeneous nature of the waste emissions will constantly vary with consequences for the speciation of ultrafine particulate emissions.

Similarly Leach [102] found a wide range of VOCs in ground level monitoring around the Marchwood incinerator pre and post shutdowns in November 1996. Although that incinerator has since been replaced the results are indicative of the range of post combustion VOCs that are likely to be found in more modern facilities.

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chlorobenzene, chlorobenzoic acid, 4-chlorobenzoic acid, chloroform, 2-chloro-6-methylphenol, 4-(chloromethyl)toluene, 2-chlorophenol, 4-chlorophenol, cholesterol., cyclohexane, cyclopentasiloxanedecamet, hyl, cyclotetrasiloxaneoctamethy, l, decane, decanecarboxylic acid, dibenzothiophene, dibutylphthalate, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dichloro-6-cresol, dichloromethane, 2,6-dichloro-4-nitrophenol, 2,4-dichlorophenol, dichloromethylphenol, 1,3-diethylbenzene, diisooctylphthalate, 2,2'-dimethylbiphenyl, 2,3'-dimethylbiphenyl, 2,4'-dimethylbiphenyl, 3,3'-dimethylbiphenyl, 3,4'-dimethylbiphenyl, 1,2-dimethylcyclohexane, 1,2-dimethylcyclopentane, 1,3-dimethylcyclopentane, dimethyldioxane, dimethyloctane, 2,2-dimethyl-3-pentanol, dimethylphthalate, 2,6-di-t-butyl-*p*benzoquinone, 2,4-di-t-butylphenol, docosane, dodecane, dodecanecarboxylic acid, eicosane, ethanol-1-(2-butoxyethoxy), ethyl acetate, 4-ethylacetophenone, ethyl benzaldehyde, ethylbenzene, ethylbenzoic acid, 2-ethylbiphenyl, ethylcyclohexane, ethylcyclopentane, ethyldimethylbenzene, ethylhexanoic acid, 1-ethyl-2-methylbenzene, 1-ethyl-4-methylbenzene, ethylmethylcyclohexane, 2-ethylnaphthalene-1,2,3,4-, tetrahydro, 1-ethyl-3,5-xylene, 2-ethyl-1,4-xylene, fluorene, fluorenone, fluoroanthene, formic acid, 2-furanecarboxaldehyde, heneicosane, heptadecane, heptadecanecarboxylic acid, heptane, 20, heptanecarboxylic acid, 2-heptanone, hexachlorobenzene, hexachlorobiphenyl, hexadecane, hexadecane amide, hexadecanoic acid, hexadecanoic acid, hexadecyl ester, 9-hexadecene carboxylic, acid, hexanecarboxylic acid, 2-hexanone, hydroxybenzonitrile, hydroxychloroacetophenone, 2-hydroxy-3,5-, dichlorobenzaldehyde, hydroxymethoxybenzaldehy, de, 2-(hydroxymethyl) benzoic, acid, iodomethane, 1(3H)-isobenzofuranone-5-, methyl, isopropylbenzene, methyl acetophenone, 2-methylbenzaldehyde, 4-methylbenzaldehyde, methylbenzoic acid, 4-methylbenzyl alcohol, 2-methylbiphenyl, methylcyclohexane, methyldecane, 3-methyleneheptane, 5-methyl-2-furane, carboxaldehyde, methylhexadecanoic acid, 2-methylhexane, 3-methylhexane, methyl hexanol, 2-methylisopropylbenzene, 2-methyloctane, 2-methylpentane, methylphenanthrene, nonedecane, 4-methylphenol, 1-methyl-2-, phenylmethylbenzene, 2-methyl-2-propanol, 1-methyl-(1-, propenyl)benzene, 2-methylpropyl acetate, 1-methyl-2-propylbenzene, 1-methyl-3-propylbenzene, methylpropylcyclohexane, 12-, methyltetradecanecarboxyli, c acid, naphthalene, N-bearing aromatic, MW, 405, nitrogen compd, MW 269, 2-nitrostyrene, nonane, octadecadienal, octadecadienecarboxylic, acid, octadecane, octadecanecarboxylic acid, octane, octanoic acid, paraldehyde, pentachlorobenzene, pentachlorobiphenyl, pentachlorobiphenyl, pentachlorophenol, pentadecacarboxylic acid, pentane, pentanecarboxylic acid, phenanthrene, phenol, phthalic ester, phthalic ester, propylbenzene, propylcyclohexane, pyrene, Si organic compd, sulphonic acid m.w. 192, sulphonic acid m.w. 224, 2-t-butyl-4-methoxyphenol, tetrachlorobenzene, 1,2,3,5-tetrachlorobenzene, tetrachlorobenzofuran, tetrachloroethylene, 2,3,4,6-tetrachlorophenol, tetradecanecarboxylic acid, tetradecanoic acid isopropyl, ester, toluene, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2,4-trimethylbenzene, 1,2,5-trichlorobenzene, trichloroethene, trichlorofluoromethane, 3,4,6-trichloro-1-methylphenol, 2,3,4-trichlorophenol, 2,3,5-trichlorophenol, 2,4,6-trichlorophenol, 3,4,5-trichlorophenol, tridecanoic acid, 1,3,5-trimethylbenzene, trimethylcyclohexane, undecane, xylene

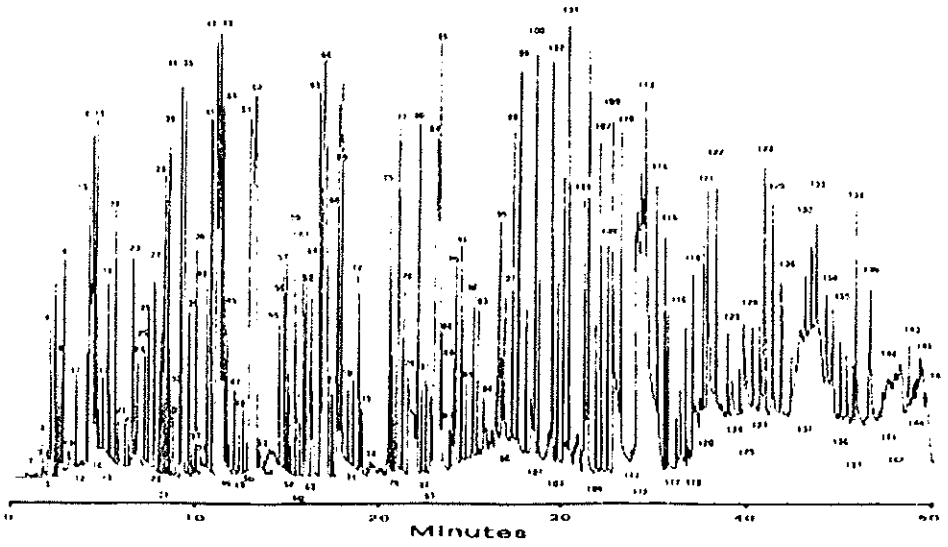

Fig. 4. Representative cGC-FID chromatogram of VOC identified at Sample Station 4, located 100 m south of Marchwood municipal incinerator (September 1996). Peak identifications are given in Table 2.

The toxicity of chemically-coated particles can be enhanced over expectations for single chemicals, because of synergies (coalitive effect, cosynergism and potentiation).

4.8 Dioxins and PCBs on Small Particles:

Fängmark et al. [13] concluded from analyzing incinerator flyash that chlorinated organics tend to be concentrated on the smaller particles. A similar result by Ruokojärvi et al. [9] found the < 1.6-μm fraction was disproportionately loaded. The distribution of PCDD/F with particle size in atmospheric dust collected at four Japanese sites was examined by Kurokawa et al. [11]. The maximum size collected was 30 μm in aerodynamic diameter, and the smallest 0.1 μm. Particles less than 1.1 μm contributed 50% of the total PCDD/F, with an almost equivalent I-TEQ proportion. The distribution of homologues changed with size, with the fraction of less chlorinated congeners in the homologue groups increasing with increasing particle size.

Chang [5] sampled air around a 1995 incinerator in Taiwan that had been fitted with activated carbon filtration to reduce the dioxin emissions to the EU standard of 0.1 ng/m3 and still found PCDD/F concentrations downwind of the MWI to be the highest and upwind to be the lowest among all sampling sites, concluding the MWI is noticeably contributing to dioxin levels in the ambient atmosphere.

Similarly Chao [103] sampled sites 1.1 and 2.1 km downwind from a municipal incinerator in central Taiwan and showed that PCDD/Fs were associated with the full size range of atmospheric particles.

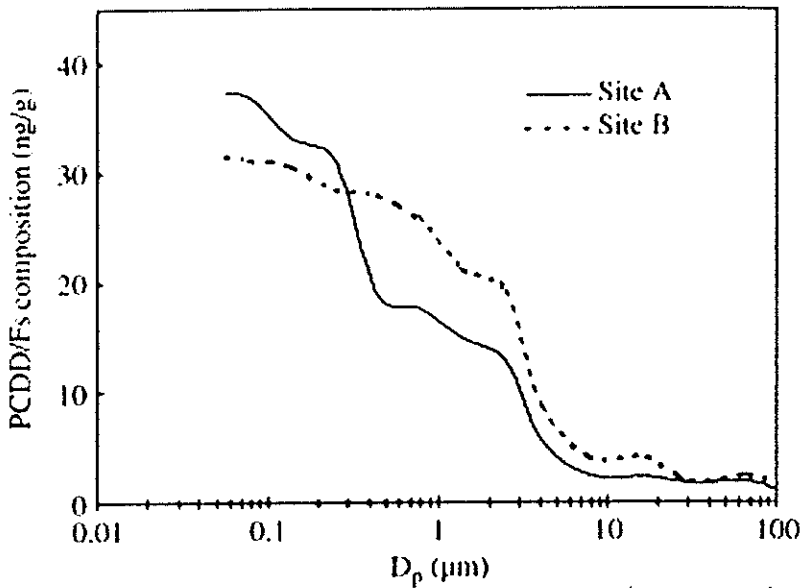

Fig8: Particle size distributions of particle-bound PCDD/Fs content (ng g^{-1})

More than 80% of the PCDD/Fs and toxic equivalents (TEQs) were found to be associated with fine particles of aerodynamic diameter 2.0 μm. Generally a smaller particle had a higher PCDD/Fs content and the dioxin concentration can be seen to increase to the very finest particles. The particle size distributions of PCDD/Fs and TEQs were shifted to larger particles with increasing time and distance.

Professor Sakai [104] analysed the mass balance of total and dioxin-like (co-planar) PCBs across a municipal waste incinerator and found that whereas the input of Co-PCBs into the MSW incineration facilities was 0.13–0.29 μg-TEQ per ton waste, the total output of Co-PCBs (the sum of Co-PCBs released from emission gas, fly ash, and bottom ash) was 4.9μg-TEQ per ton waste. Whilst over 90% of the total PCBs were destroyed in the incineration process the toxicity of the output was found to be higher than that of the input. This emphasizes the importance of assessing PCB emissions as well as those of dioxins and as the indications are that PCB synthesis was taking place post-combustion it is likely that the contaminants on the smallest particles would include PCBs as well as dioxins.

4.9 Halogenated Dioxins

It should be noted that whilst currently 17 dioxins and furans are measured there are actually many more – and this has been recognised for more than 20 years. In 1987, for example, Schechter [105] wrote:

"We are faced with the problem that animal data, upon which risk assessment and standard setting is based, is very incomplete. Also, as noted by Buser, in addition to the 200 plus chlorinated dibenzodioxins and dibenzofurans which may exist, there may be 5,000 chlorinated, brominated or bromochlorodioxins and dibenzofurans which may exist from incineration sources and which may be of potential concern".

Since 1987 it has been demonstrated beyond doubt that brominated and mixed halogenated dioxins are produced by incinerators and that their toxicity is similar to - and sometime greater – than the chlorinated dioxins. In spite of this these dioxins are still not incorporated into incinerator risk assessments.

4.10 Combined Particle Size Distribution and Speciation:

Unfortunately few researchers have combined data on particle size distribution and speciation. Greenberg [106] tested emissions from the Nicosia incinerator and found 70-90% of the Zn, Cu, Cd and Pb to reside in the smallest particles (< 0.8μm). However, that facility had only an electrostatic precipitator at the time, so the results are not directly transferrable to a more modern plant with a bag filter. Nonetheless it is clear that the majority of the metals exposure should be anticipated to arise from the ultrafine fraction of the emissions.

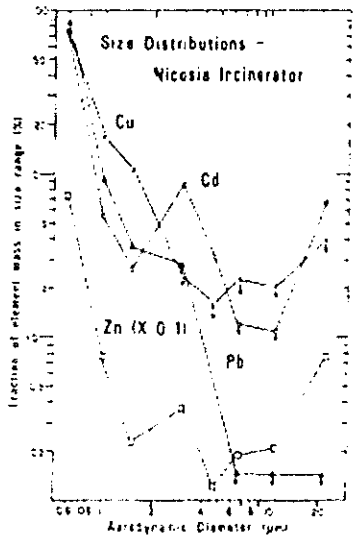

Figure 2. Size distributions of particles bearing indicated elements in terms of stack-gas mass concentration of the element (i.e., total mass per unit volume times elemental concentration in mass) vs. particle diameter, normalized to 100% for each element
Data obtained from analyses of material collected with cascade impactor. First stage collected all particles with $D > 15$ μm; last stage (backup filter) collected particles <0.6 μm

4.11 Future Risks – Disposal of Nanotechnology wastes:

Nanomaterials are already reportedly used in over 800 products and the sales of which were valued at $147 billion in 2007 and are expected to soar over the coming years with a predicted value of $3.1 trillion by 2015 [107]. Inevitably the quantities of waste containing nanoparticles will increase rapidly but little thought has yet been given to the consequences of this. When products are incinerated, the thermal properties of nanoparticles determine their fate. There is evidence that at least some nanoparticles will pass through incinerators and be dispersed into the environment..

Franco [108] writes: *" whereas the onset temperature reaction for C60 is very low (315 °C), carbon nanotubes display very low reactivity under combustion conditions (onset temperature = 820 °C) and hence may not breakdown in an incinerator [109]. In theory, this means that they could end up in the gaseous effluent and released into the atmosphere".*

This is a significant concern given the inability to filter ultra-fine particles even with modern bag filters [78-81]. Any nanoparticles released from an incinerator increase the risk described above and incineration may increasingly play a role as a very effective delivery mechanism directly into the alveoli for a wide range of products of waste nanotechnology products.

4.12 Risk Assessment:

The risk assessment in relation to particulates that has been undertaken by the Indaver is rather simplistic. The principle assumption, and the basis for the conclusion, it that if air quality standards are not exceeded by the combination of existing ambient concentrations and the marginal increase from the incinerator then no harm is assumed to occur.

This approach is, of course, fundamentally flawed for those emissions, like particulates for which no safe level can be demonstrated.

Kunzli [110] wrote *"In many countries, policy makers currently face the problem that air quality criteria regulations are intended to "protect health", including the health of the most vulnerable people; to date, research has failed to obtain any evidence for a no-effect threshold. Thus, similar to carcinogens, the natural "threshold" might be zero exposure. Therefore, non-zero target values of clean air acts, inherently assume that some health impact of air pollution may be accepted. Impact assessors must choose a level below which they explicitly want to ignore the impact on air pollution"*.

Chao [103] comments that even though a large number of atmospheric dispersion models exist and are readily available for use, the risk assessor is generally faced with little or no data on the atmospheric particle size distribution of PCDD/Fs. Lohman and Seigneur [111] conclude that *"it is essential to obtain accurate characterizations of the particle size distribution of particulate PCDD/F because the dry deposition flux is very sensitive to the particle size distribution"*. Without such data accurate risk assessment is not possible and yet there is no evidence that it has been collected or used in relation to this application.

4.13 Conclusions on UFPs from Incinerators:

Not only do a high proportion of the UFPs escape the filters, but they are chemically reactive and carry a wide range of products of incomplete combustion and adsorbed metals with them. The subsequent direct uptake of these respirable particles and the ready transfer from the lungs into the blood stream may be part of the reason that traditional toxicology is at a loss to explain the level of impacts for such apparently low exposures.

Aerosols in the ultra-fine size range have much higher mobility in the air and can more effectively deposit in the respiratory system.

Ultrafine particles have been found to be chemically highly reactive, even when originating from a relatively unreactive bulk material [25]. The massive surface area associated with a small mass of nanometre-sized particles can act as a catalytic surface for the secondary formation of organic compounds such as the *de novo* synthesis of dioxins.

The relative toxicity of ultrafine particles arising from different processes remains un-researched. The levels of heavy and transition metal inputs in municipal solid waste are very much higher than with conventional fuels. Such increases must inevitably be associated with an increase in toxicity and consequently the likelihood of adverse health effects among the local receptors.

In my opinion, there is also a need to determine the relative toxicity of the particulate aerosols in the gases emitted by different waste disposal routes, to facilitate rational decisions as to the best disposal method, particularly with respect to public health. This should be addressed urgently but, in the meantime with the significant prospects of serious harm to health, high weight must be given to the precautionary principle.

5 The Precautionary Principle

The Twenty-fourth Report of the Royal Commission on Environmental Pollution, *Chemicals in Products: Safeguarding the Environment and Human Health,* [112]pointed out that the historical record is replete with unexpected toxicological impacts arising following the use of anthropogenic chemicals.

The Royal Commission emphasized that whilst we have learnt a great deal from some of the early episodes we may still be caught unawares, as witnessed with the emergence of a large number of different endocrine disrupting chemicals during the 1980s and 1990s.

"It was not foreseen that low concentrations of chemicals used as antifouling agents (tributyltin), surfactants (nonyl phenol), flame retardants (polybrominated diphenylethers) and plasticisers (phthalates) would bind to hormone receptors or disrupt hormone metabolism in birds, reptiles, fish and invertebrates and influence sperm counts and the development of testicular malignancy in humans [113, 114]."

These examples refer to chemicals whose reactivity it was felt was reasonably well understood. This is not the case with the UFPs with their wide range of chemical loading that are released in large quantities from modern incinerators. Apart from the fact that we know they are likely to be harmful at concentrations well below current air quality standards little is known of about the likely extent of environmental effects or their likelihood of causing unintended harm. Furthermore as nanotechnology expands there are even greater future risks from relying on technologies which, in at least some cases, are more likely to disperse them into the atmosphere than to destroy them as described above.

Having reviewed the science and the hazards of ultrafine particles I agree with Kunzli [110] who wrote *"In the light of all the uncertainties and limitations, researchers should not lose sight of the general patterns and perspectives. Given the current level of evidence of the association between air pollution and health, the precautionary principle may provide excellent guide to rigorously implement clean air strategies".*

The precautionary principle is part of the framework for sustainable development and I consider that the principle should be regarded more seriously when considering incineration processes, where there is significant scientific uncertainty and serious risks of harm.

The precautionary principle in its modern formulation is a means to safeguard public health. The European Commission advised the inclusion of public health in 2000 (European Commission Communication on Precautionary Principle, 2 February 2000), saying that the precautionary principle should be applied where *"there are reasonable grounds for concern that potential hazards may affect the environment or human, animal or plant health, and when at the same time the lack of scientific information precludes a detailed scientific evaluation".*

The EU Treaty Article 174(2) as amended at Nice 2004 recognized that scientific evaluation can be inconclusive and accorded priority to public health:

> a precautionary approach must be paramount, as opposed to acting only where proof or very strong suspicion of harm can be demonstrated. The Precautionary Principle should be applied where the possibility of harmful effects on health or the environment has been identified and preliminary scientific evaluation proves inconclusive for assessing the level of risk. Account should be taken of social and environmental costs in examining the level of risk, but the protection of public

health, including the effects of the environment on public health, must be given priority.

I would therefore recommend that this application should not be approved in the light of the likely risks to public health and the Environment detailed in this evidence.

6 EndNotes:

1. Maynard, R. and C. Howard, Eds, *Particulate Matter: Properties and Effects upon Health.* 1999, Oxford: BIOS Scientific Publishers.
2. European Commission, *DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 December 2000 on the incineration of waste.* Official Journal of the European Communities, 2000. **L 332**.
3. Health Research Board, et al., *Health and Environmental Effects of Landfilling and Incineration of Waste – A Literature Review.* 2003, Dublin: Health Research Board. viii, 284 p.
4. World Health Organisation, *Population health and waste management: scientific data and policy options Report of a WHO workshop Rome, Italy, 29-30 March 2007.* 2007.
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ANNEXURE-RJ-IV

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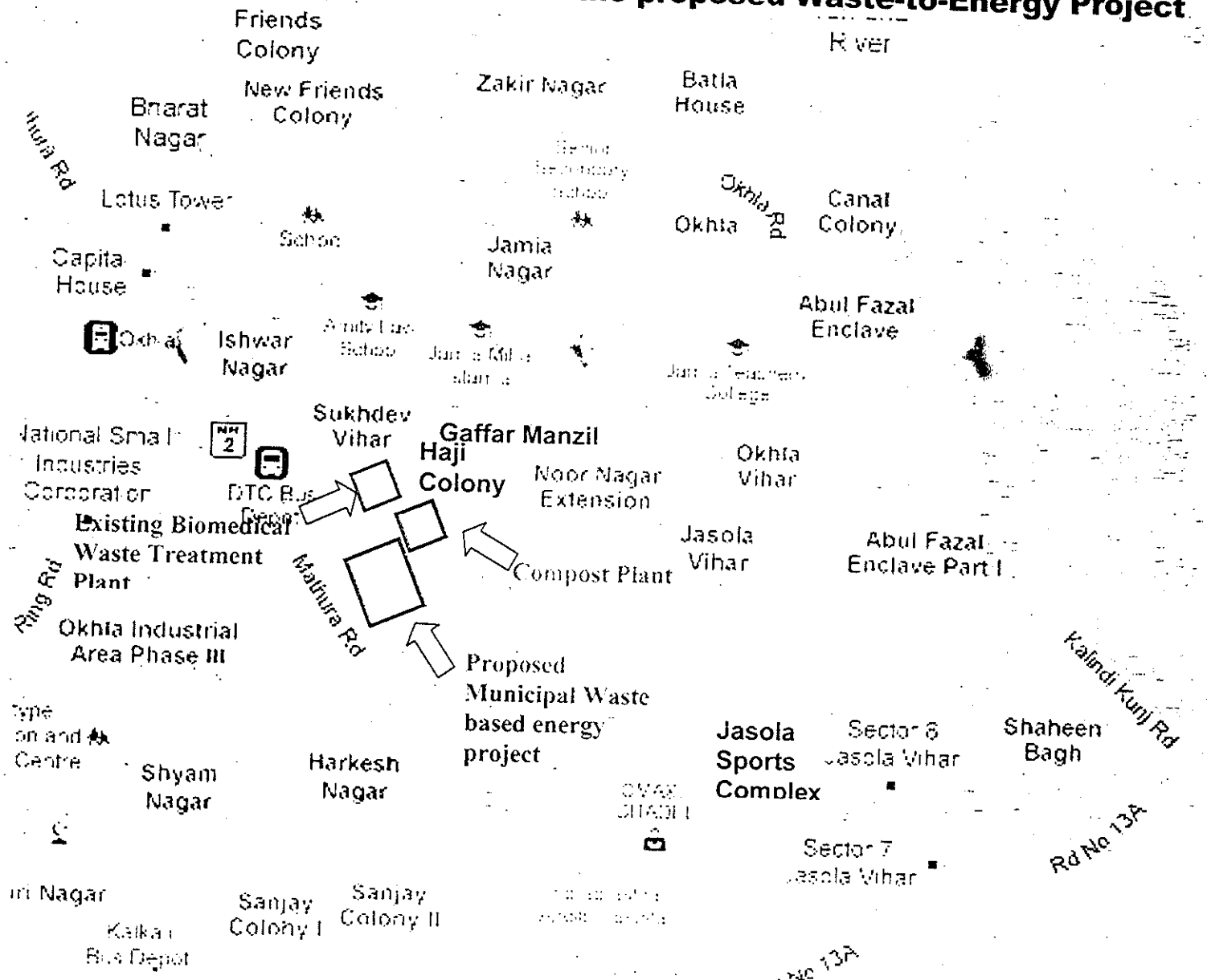
Site Map of the area around the proposed Waste-to-Energy Project



Source: @2009 Google Map