Mine dust workshop summary 19 July 2018

This is the third mine dust workshop held as part of this initiative. The minutes of the previous meetings held in 2016 are available on the shared folder. This group was started with Jenny's visit to an AAUN (Australia Africa University Network) meeting held by Helen McDonald on mining and health mostly attended by health anthropologists and occupational hygienists. From this meeting it became clear that mine dust is one of these intractable problems that spans many different disciplines and can only be dealt with by an inter-disciplinary, multi-stakeholder group of people which are two aspects that defines sustainability science. In the last two years we did have some cross collaboration between members of the working group as a result of the initial meetings in 2016. We are now ready to build research capacity and drive this initiate further.

The complex nature of the problem of mine dust lends itself to adopting a collaborative approach to solving the problem. Several invited speakers gave presentations to give insight into the problem of mine dust from their respective fields. The purpose of this workshop is to try and identify specific areas that this group can focus on. To better understand the problem and to start channelling our thinking towards how we might address this problem.

Discussion outcome

A decision was taken for this group to adopt a two-tiered approach. A high-level group which will include all interested parties or stakeholders from all sectors (like the present meeting) to define what the problems are that merit further investigation and sharing information and findings from their respective sectors. A second level of collaboration would focus on investigating the identified problems and finding solutions. Depending on the focus of the research, these smaller more specific groups will be made up predominantly of independent researchers and scientists with no vested interest in the outcome of the study at hand. The findings from the studies preformed by specific research focused groups will then be presented to the larger forum for comment, potential implementation and future research opportunities.

Several participants felt that the issue of conflict of interest needed serious consideration (especially attendees from the School of Public Health) and that it won't necessarily be in the interest of industry and other stakeholders to support the type of questions that scientists are interested in answering. A two-tiered approach was suggested for this workgroup and the collaborative work it undertakes. The first tier, high-level group will involve defining of the problem by all stakeholders but when it comes to the actual research, the issue of conflict of interest is a very important consideration. Most research involves investigations of technical issues and that is where scientists, researchers or people with the necessary specialist expertise come in. The results will then be handed back to all the stakeholders for consideration and comment.

We are currently in the process of scoping relevant funding opportunities and already have some student projects running at the moment.

Attendees:

Name	Organisation	Name	Organisation
Jennifer Broadhurst	UCT Chemical Engineering	Fanus van Wyk	Agreenco
Megan Becker	UCT Chemical Engineering	Eugene Cairncross	CER, Emeritus Professor (Chemical Engineering)
CK Kamanzi	UCT Chemical Engineering	Jim teWaterNaude	Occupational medical physician
Juarez Amaral Filho	UCT Chemical Engineering	Marlon Saayman	Transnet
Patricia Kooyman	UCT Chemical Engineering	Johanna von Holdt	UCT Chemical Engineering
Petr Konečný	UCT Immunology	Mazimkhulu Zungu	NIOH
Rodney Ehrlich	UCT Emeritus Professor (Health Sciences)	Brian Chicksen	AngloGoldAshanti
Cheri Young	UCT Law faculty	Koketso Molepo	UCT EGS
Claire Fitzgerald	UCT Anthropology	Bernard Kengni	UCT Law faculty
Mohamed Jeebhay	UCT Public Health	David Viljoen	UCT Grant writer
Shahieda Adams	UCT Public Health	Dionne Miles	UCT Grant writer
Mary Miller	UCT Public Health	Saul Roux	CER
Mutsawashe Mutendi	UCT Anthropology	Sally Benson	Western Cape Government
Harold Annegarn	NWU and China Agricultural University	Joy Leaner	Western Cape Government
Sue Harrison	UCT Chemical Engineering	Elisee Byelongo	UCT Chemical Engineering
Ódri Ágnes	UCT Chemical Engineering	Jochen Peterson	UCT Chemical Engineering
Jochen Peterson	UCT Chemical Engineering	David Viljoen	UCT Chemical Engineering

Presentations

Mutsawashe Mutendi	*"Oh! That dust is powerful hey."*: Unpacking mine dust as a form of violence
Eugene Cairncross	What is the health risk of coal mine dust in South Africa?
Ck Kamanzi	New horizons for air quality: Integrating individual particle analysis with current dust monitoring strategies in South Africa.
Cheri Young	Mine dust: barriers and shortcomings in the law
Petr Konečný	Silica associated toxicity
Shahieda Adams	Investigating the link between silica exposure and TB
Fanus van Wyk	Engineering tailings facilities for reduced dust emissions in South Africa
Harold Annegarn	Implications of the revised National Dust Control Regulations (May 2018) and unresolved dust issues.

Presentation summaries and extracts

"Oh! That dust is powerful hey.": Unpacking mine dust as a form of violence

Mutsawashe Mutendi

Mutsa completed her MSc in social anthropology on understanding TB from the miners' perspectives. One of central themes was the notion of dust and that when you ask miners where TB comes from they say it comes from mine dust. Mutsa had to argue in her research that their views were not inaccurate. If you think of the relationship with dust and the potential it has to increase your susceptibility to get TB. This research set out to capture dust and one of the ways it came through in this research was dust as a form of violence and using the theory of slow violence by Rob Nixon. It's a theory that talks about environmental planning, about what we are doing to the environment now as being invisible. We can't see the damage we are doing to the environment now but one day we will be able to see it. This is an Interesting concept to tie up with the narratives with Mutsa's research informants because they spoke about the dust and inhaling the dust and how it was slowly killing them. How it represents itself in TB or through silicosis. This is one of the ways we can try to make sense of dust as a form of violence. We can draw on a few narratives to contextualise this:

Sipho started working in mines in 1997 and left in 2003. He complained that when he worked underground it was dusty and that he was suffocating in a way and that he couldn't breathe because of the dynamite that he was exposed to. For him it was mine dust because he only contracted TB 4 years after leaving the mine. For him TB was located in the mines.

Amo was a safety officer at Impala platinum and spoke about TB and where she thought TB comes from "It's safe to say I got TB from the dust. Oh, that dust is powerful hey! It's funny, we are only taught about fall of ground and how they are so dangerous. But no one ever warns you about the dust and the damage it does to your body. There is so much dust there we can't even see each other. Everything is covered in dust, there is dust in the air, at the ventilation sites, on the walls, on the tunnels, on my tongue, hands, face, overalls and even on my work tools. Sometimes at the end of my shift, my body is covered in a thick layer of dust, but the worst is the taste of the dust of the explosives."

Both Sipho and Amo have had TB and that is where the invisibility of that damage materialises in the body of the miner. Dust also lends itself in other forms of social violence afterwards in the sense of retrenchment. What happens to a miner once they contract silicosis is essentially that the mining company almost spits them out when they are of no value. That was one of the things Mutsa tried to bring out with the notion of dust and the violence of dust - how this form of invisibility leads itself to other forms of social and institutional violence.

Wrapping up with another narrative from Amo, she said this whilst we were at an underground visit and she was pointing at a wagon full of platinum: "This is what I am dying for, these rocks are so valuable, this wagon will probably be worth more than three months of my salary, it is worth so much I know the mining company must be making a killing. You would think that they pay me a decent amount for the dangers I see underground and the dangers that it does to my body. What do you think the dust is doing to my inside? Sometimes I ask myself is it even worth it? Every day I risk my life for this rock. I've had TB twice, surely that kills you slowly. It's not fair that I risk my life and health when it is not even guaranteed that I will make enough money to put food on the table at the end of the day. No regard for our suffering, to them it is all about making money."

What is the health risk of coal mine dust in South Africa?

Prof Eugene Cairncross

Dust emissions occur during the full life cycle of coal mining with operations from production through to consumption in power stations, through to the dumping of the residue both from the power stations and the mining activities. Coal mining operations and related activities cover an extensive land area. It's pervasive over a large part of especially Mpumalanga and about half of coal mines are surface mines which means they have a particular set of problems associated with it. Discard residues are widely distributed, and combustion ash deposits covers a large surface area. Population exposure and health risks to coal mine dust is unknown. We think of the dust affecting mine workers, but it is the general population that is not recognised as being exposed to coal mine dust and therefore the health risks are also unknown.

Since 2007 coal production averaged about 250 MT a year. 30 % exported and at current production rates, Eskom power stations accumulate 33 MT of ash per year with a total accumulated ash deposits of the order of about 500 MT to date (probably more). The discard coal of various types amounts to 1.9 BT of material spread around. Although it is difficult to get this figure we can estimate from a survey done in 2001 which set the base estimate at 1.1 – 1.2 BT and with ratio of discard to coal produced of about 1/3 and taking total production since 2001 we, arrive at a figure of 1.9 BT.

Licences for prospecting have been issued for just about every square km of Mpumalanga (see map). This relates to the poor governance picture that licences to prospect is just being issued. Once you have a license to prospect you basically have a licence to mine since it is very difficult to stop mining from going ahead. So, prospecting licences have been issued throughout the province without regard for any other activities or impacts or implications of that.

Coal mine dust is a health risk. There are two possible routes of exposure, the one is inhalation of the actual dust (only have time to deal with this one in this presentation) and the other is ingestion when dust settles on surfaces, crops and plants. When the dust is ingested, or eaten, the estimation of health risk involves a different methodology to inhalation. Kids are particularly vulnerable because they play in the dust.

There is a need to do a health risk assessment for the general population that are being exposed to coal mine dust, especially from discard residues. This would require an assessment for inhalation and ingestion. Eugene went on to set out the steps that would be required to perform such a health risk assessment for inhalation of PM2.5. Firstly, when performing a burden of disease, it is necessary to identify a particular subset of relevant diseases. Secondly, determining the annual average concentration of PM2.5 that people are exposed to is difficult given the large area covered by these activities and residues and the absence of adequate monitoring stations. The emissions are by and large intermittent, initiated by various mining activities, coal truck moving, excavations, blasting and so on and wind speed, relative humidity, surface characteristics and other meteorological characteristics. All these factors influence the intermittent release of dust. The sources are dispersed and irregular in shape and there are different surface characteristics, such as the particle size of the dust and whether it is covered with vegetation or not. To do this estimation you need an emission model that puts a whole lot of factors that you do know together and estimates the emissions.

Once you have this gridded picture of ambient average concentrations as a measure of exposure you have to map the population onto that to provide a population-based exposure or how many people are exposed at a certain concentration level? Once you have mapped the exposure on top of the population, the next step is to have a relationship between exposure and the health risk or health outcome. We have this rather complicated model or estimate of the relative risk as a function of exposure. Relative risk for the exposed person relative to the risk of a person that is at a minimal exposure level. We need the Integrated Exposure Response (IER) function done by rather complicated iterative calculation that gives you the 95% confidence interval and error bars. We use these to generate the Population Attributable Fraction (PAF) and health risk calculation.

The other part, the risk associated with the ingestion of the dust, the dust that settles around the population living much closer to the source, their children playing in the dust, people getting dust in their food and so on. If you listen to the stories of people living close by, you will see how it impacts them, this pervasive dust, they can never get things clean. This requires a totally different methodology which we can't even outline at present.

New horizons for air quality: Integrating individual particle analysis with current dust monitoring strategies in South Africa

Ck Kamanzi

The overarching aim of the talk was to propose an integration of individual particle analysis with current dust monitoring strategies in South Africa. There is a sense that air quality is something the public takes for granted and as such, we start to question if air quality is an actual cause for concern and whether the general public and reporting officials should care.

In the more recent sense various platforms have published evidence on the measured morbidity and mortality rates caused by exposure to airborne pollution. The prevalence of such information has been extensively reported on by the media, such as an article published in The Guardian in May of 2016 titled "Air pollution rising at an 'alarming rate' in world's cities". This article investigated the rampant rise in air pollution within some of the world's global cities. In this article they quote results presented by the World Health Organisation (WHO) stating that about seven million premature deaths occur each year globally due to air pollution.

Currently we are beginning to see correlations between what we release into the atmosphere and the impacts which people are facing on the ground. Understanding that this issue is highly complex and multifaceted, one can begin to question what is the 'best way' to arrive at a solution. It has become apparent that a case study-based approach is a good way of 'chipping away' at the problem at hand. This allows for the development of fundamental information for frameworks and strategies for the broader scale issue as well as providing solutions for a specific case.

Coal dust emissions from the Waterberg coalfield in Limpopo presents an ideal case study and to interrogate our current monitoring and measuring strategies. To give some context to this, the major focus (in terms of priority areas) on air quality management is directed to our major cities and our coalfields in the north of SA. In 2005 the Department of Environmental Affairs (now Dept. of Environmental Affairs and Tourism-DEAT) published the National Environmental Management: Air Quality Act No 39, which was amended in 2014. Between the time of inception and the last amendment the declaration of priority areas as well as various standards to monitor air quality were created. Another auxiliary system that has come from this piece of legislation is the South African Air Quality Information System (SAAQIS), this system reports hourly concentrations of particulate matter as well as other air pollutants. This information is archived within this system, which houses data from 2005 up till current.

To understand why we should investigate individual particles within dust plumes, it would be useful to first have a general understanding of how air quality monitoring has changed and evolved over the years. Previously, air particulate concentrations were determined using Total Suspended Particles (TSP) which recorded bulk particle concentrations of particles in dust plumes. As a result, the chemical signatures were averaged out by taking the bulk fractions. Subsequently, epidemiological studies have been reporting that there are certain size fractions which can be deposited and retained in your lungs and as a result, monitoring strategies changed to measuring PM10 and PM2.5 as criteria pollutants. This led to the investigation of the individual particles in the plume based on the size of the particles. Currently, the thinking is around whether or not we should be reporting on the physical and chemical characteristics of the dust particles themselves and what this actually means for dose? The term dose is defined as the summation of the bio-persistence and the physical and mechanical removal processes in the lung. It can arguably be said that particle characteristics have a significant impact on these mechanical and physical removal processes.

My research proposes the development of a protocol for analysing dust particulates using individual particle analysis. Previous research found that South African coalfields are generally high in mineral matter such as quartz and pyrite and that it is important to consider how we define the toxicity of the mineral phases present in dust (Mineralogical characterization of particulate matter from the Witbank coalfield to investigate ambient air quality, Honour's thesis, CK Kamanzi).

Another finding of this research was that one can successfully quantify particle characteristics, although these characteristics are based on metrics defined by process mineralogy. I attempted to integrate the quantified particle characteristics along with the emission data that is publicly available from the South African Weather Service (SAWS). This was done with the intension to forge linkages between the potential dust particles which can be respired and the emission sources which are measured.

In my master's research I intend to look at a more application-based approach with the intention to develop a protocol for characterising particulate emissions from coal mining and processing. The focus will be on quantifying particle characteristics determined and defined by the concept of toxicity for ultrafine particulate matter. The case study that we have chosen for this project will be based in the Waterberg coalfield in Limpopo as this coal has a high mineral content, the site is relatively isolated and has no proximal overprinting industries other than the adjacent power station and the coalfield serves as the last volumetric source of coal in South Africa. The aim is to develop a complementary suite of techniques which will quantify particle characteristics in a reproducible way, where the intended output of this research will be to assist measuring and monitoring bodies in their risk definition by providing data and creating input parameters that can be used for future dispersion models.

Mine dust: barriers and shortcomings in the law

Dr Cheri Young

Cheri gave a brief overview of the legal framework pertaining to mine dust and some of the shortcomings or gaps or barriers in the legal framework that this particular focus group can assist with. Often what we find with lawyers or legal academics is that we are quite good at the paperwork and reading the books but not so great at understanding how it operates in practice and this is evident from the experience of a number of interdisciplinary groups, that lawyers stand to gain far more from scientists than the scientists can gain from the lawyers.

The legal framework aims to take care of and take into account different stakeholder interests and requirements. As such the legal framework in the context of mine dust, for example, looks at the responsibilities of the state. What are the powers and the duties that the state must fulfil in regulating the environment. In this respect, there are three key criteria or duties that state must fulfil: on the one hand there is a planning objective, the state has a broad planning or oversight function to take into account all of the country's objectives. As one of the previous speakers said - take a custodial role of statistics so we have the big picture idea of what is actually going on, not only at a national level, but also at a provincial and local level. There is also a monitoring and oversight function. Once certain terms and conditions have been put into place, the state is required to monitor and provide some level of oversight to see whether those objectives are actually being fulfilled. That could be on the part of other state entities for example, are they actually developing their plans timeously. It could also be from the perspective of right holder, for example a mining company, once they have been given certain rights and licences are they living up to the terms and conditions that they are expected to fulfil. The last role I want to highlight is the enforcement obligation of the state. Once the state sees there is a gap, or the rights and obligations are not being fulfilled, the state is then responsible to ensure that there is some kind of penalty or obligation that is imposed.

The legal framework also sets out the company's obligations to some extent. To the extent that the legal framework can provide every different permutation of a factual scenario it does try to set out what companies must do in terms of scenarios and also sets out the duties and commitments. What we know is that the legal framework generally tries to provide the guidelines for conduct. It can't set out each variable for each circumstance. As lawyers what we struggle with is knowing how to apply the law across the board in a variety of circumstances because it doesn't say: "If X, then Y" for every variable that exists. What happens is you will find a general guideline; the law will say you must submit a report and it must contain the following five things. But what the scientists will tell us is that that is wholly inadequate for what occurs on the ground. The other stakeholder that the law tries to take into account and protect is then societies and communities. Particularly in the context of mine dust, the law is trying to protect your employees and the environment is a big consideration as well.

The focus of this legal presentation is really on the environmental framework. The legislation covered specifically deals with the environmental law. Our framework legislation consists of the constitution which is our supreme law, and everything must be consistent with the constitution. We have a section 24 which aims to give effect to a healthy environment which includes the right to wellbeing. This has bene broadly interpreted in the courts. This is again one of those vague terms that is very difficult to apply in practice. What does it mean for an environment to realise somebody's wellbeing. The courts have said this and in fact our legislation also says that this could include even cultural factors and so cultural and social factors have been included into the legal framework. The framework legislation for the environment generally is the National Environmental Management Act. This act in the main attempts to give the rights and duties of a state or powers and obligations of a state or the government. Generally, the Dept of Env Affairs is responsible for management and protection of the environment and if you were a company you would apply to them for a certain right. Peculiarly, in the context of mining all rights and licences have been removed from the sphere of authority of the Dept of Env Affairs and given to the Dept of Mineral Resources as part of what is called the One Environmental System. As a result, we have this peculiar situation where the Dept of Mineral Resources' mandate is to mine (an inherently economic function) but they must give effect to what are inherently environmental obligations in terms of the NEMA legislation. NEMA provides a definition for pollution which includes dust and you have to read that together with the other framework legislation which deals with air quality which is the National Environment Management Air Quality Act (NEMAQA). Those two acts works together. Air emission licences are applied for in terms of the air quality act. NEMAQA says that air pollution means any change in the composition of the air caused by smoke, soot, dust (including fly ash). There the act gives express recognition that dust is considered a form of pollutant in terms of our environmental legislation. Then as a subordinate to this framework legislation we have the National Dust Control Regulations of 2013 (currently under review, should be revised by 2019). Under the current regulations dust is defined as any settleable particulate matter, meaning any material composed of particles small enough to pass through a 1mm screen and large enough to settle by the virtue of their weight into the sampling container from the ambient air. This definition is regarded as being hugely problematic in the context of silicosis for example in that this measurement of dust is more likely to be the heavier particles that will settle but it is actually the lighter dust that causes health issues and that might not be the dust that settles. The regulations that provides for the measurement standards is ASTM D1739, those set out the measuring criteria for dust and this measurement standard is seen as problematic.

NEMAQA recognises that the quality of ambient air in many areas of the republic is not conducive to a healthy environment. The burden of this falls most heavily on the poor, the law already recognises that we have a problem. That the stakeholders who are being most heavily impacted are the poor in our society. Again, the law already recognises this and has recognised this for many years. Everyone has a constitutional right to an environment that is not harmful to their health or well-being and the right to have the environment protected.

What our air quality act tries to do is control the functions of the state through a number of mechanisms that requires planning and programs to be implemented. It requires the national level to implement what are called air quality and emission management standards. It requires the declaration of priority areas, for example, the Vaal Triangle Priority area that has been declared. I've had a look at the regulations and they don't say anything helpful in terms of what that management plan is meant to be doing. We have listing and licensing requirements that once an activity is listed you must apply for a license in order to undertake that activity. Mining is such an activity and if you want to undertake mining, you must apply for an air quality emissions license before you start. Again problematically, the law prescribes what happens if you don't have that licence. If you operate without an air quality emission licence you will be subject to a fine of only R200,000 which is not a lot to a mining company. Similarly, the fines in the context of violations of the air quality act is a maximum of R5 million. That is not necessarily a penalty that a mining house is going to feel. The act also sets out the requirements for control of dust and mine rehabilitation with regulations that have been published, with offenses and penalties.

What are the shortcomings in the law? There are many but some of biggest ones are that our measurement standards are inadequate particularly for the type of crises we are facing in the context of dust. The second issue that is hugely problematic is the transparency and accountability in this sector and we see this across the board with the mining sector. We don't actually know what is contained in the rights and obligations or plans and promises that are made by companies to government. Similarly, we don't understand the negotiation process between government and these companies when licences and rights are being awarded. This is problematic because it gives us nothing to work with, we have no actual information in terms of what's going on on the ground practically and how stakeholders such as the environment, communities and society are being protected. This is problematic from the perspective of enforcement and monitoring because is government doesn't have the capacity to monitor and enforce these requirements and we rely on people such as the Centre for Environmental Rights or other stakeholders in civil society, they don't necessarily have the information that they need to ensure that there is any kind of consistency or enforcement of the law. Finally, the nature of these dust problems is that they are long term problems. Silicosis often only transpires many years after workers have worked under the ground or environmental problems are only exposed decades after they take place. We know that the legal framework is problematic in that it doesn't actually connect the polluter with the polluter pays principle down the line. That is again not necessarily a problem with the legal framework because the legal framework recognises this. It is more a problem in terms of implementation.

Silica associated toxicity

Dr Petr Konečný

Peter is a postdoc in the Division of Immunology and his presentation was based on work he has been doing over the past two years. This is one of the first studies that resulted from the first mine dust workshop in 2016. This project involved the reaction of silica particles with mycobacterium Tuberculosis and disease pathogens and progression.

The main objective of this study was to establish the Silica platform within the Immunology group at UCT which ended up being the most challenging thing of all. In addition, to evaluate the pre-radiological response to silica. It is known that silicosis is very commonly associated with tuberculosis and the lung damage can contribute to the infection of Mycobacterium, but we were trying to find out if there is a relation between silica itself and its impact of the immune system of the host and then to identify the mechanisms leading to susceptibility to TB after exposure to silica particles.

Silica causes high susceptibility to TB infection as well as potentiation of disease progression in severity especially treatment outcome. Treatment of TB in people with silicosis does not work as well as people with only Tuberculosis. It also helps to reactivate latent TB infection.

What is the connection between silica an TB? It's that both mycobacterium and silica get engulphed by macrophages as the first initiator and first contact upon inhalation and we don't really know what happens in certain stages of the cycle. We were trying to find out the immune response of a person that is exposed to silica and what happens after.

What is known and unknown in silicosis research? The TB profile is very well established, obviously there are some things that are still not known but we know what innate and adaptive cells are doing after exposure to TB. If we look at silica itself there's been extensive research focused mainly on macrophages, the initial interactive cells upon inhalation. The recruitment of other immune cells or components upon the reaction of silica and the basic production of cytokines is known but there is significant inconsistency in the results. If you go through all the papers, you will see that one says that silica particles do that and the other is going to say that it does completely the other thing. This is a factor that causes problems for further research because there's nothing to grasp, there is nothing to follow on because you'll see that the only information you'll get is that silica is toxic, that it causes trouble, that it causes diseases, it causes susceptibility to other diseases, but we don't know why, we don't really understand the mechanisms of the whole exposure process. If you look at the research regarding silica and TB together, there is very little done on that. We don't really know what properties of the silica particles the toxic features are, we don't know the process of interaction between silica and mycobacterium TB directly, if the silica itself interacts with mycobacterium and if that is how it helps the progression of disease, we don't know the mechanisms of susceptibility towards mycobacterium. The most important thing is that silicosis or silica is actually a persistent disease, it doesn't go away. It's there for years and there has been very little research done on the chronic modulation of the immune system. We don't know what happens after a certain time of exposure when it sits there and causes the chronic modulation of immune system which involves chronic recruitment of immune cells, modulation associated with autoimmune diseases, antigen presentations, cytokine production and granuloma formation modification. There is almost nothing done on these.

The main question arose, what is the toxic feature of the silica particles? Dust is a very heterogeneous, there are a lot of particles of different size, in different shapes, chemical components and admixtures. There are some papers that have focused on the toxic features of the silica itself: size, shape, age, crystallinity, chemical properties, admixtures and many more. Some have been excluded already, like crystallinity and now we know for example that crystalline silica can be toxic the same way as amorphous ones and as such crystallinity is not actually the issue. Size, shape, age, there is not much done on those aspects, so we don't really know. Admixtures, a very important feature because for example if you have mixed dust, heterogenous dust, clay components of the dust can have a protective effect against the silica particles and many more features which can confuse and cause changes in the outcome of what we would do if we exposed the mice or the cells to those particles. The recent studies were focusing more on the surface properties and they are claiming that the toxicity is caused by the reaction sites on the surface of silica particles such as silanols and siloxanes. The hypothesis is then: it is known that freshly cut particles are more toxic than the old ones, which makes sense because the old ones are abraded and not as rugged, they reacted with their environment and cause them to block off other reaction sites on the surface. If you cut silica particles you have a surface full of silanols and siloxanes in a different ratio. We wanted to develop or manufacture a standardised model of silica particles which we would be able to use in our research, which would be homogeneous and pure with specific silanol concentration or orientation. Therefore, we would only have a few parameters to look at and to see if these are toxic features or the toxic properties of the particles. To do this we collaborated with chemical engineering at UCT and attempted to answer the question whether Min-U-Sil is the appropriate experimental model for biological activity assessment. We tried to manufacture particles in the respirable sizes: 1 - 10 microns. It was a very, very tough task because we followed 12 to 15 different papers which claimed that you can make particles up to 10 and 15 microns which is impossible. We ended up with different groups of particles of different silanol groups on the surface and it was spherical particles of a certain size: 1 micron ± a few nanometres and different silanol group concentrations. These were tested for cytotoxicity ion uptake to find out if these silanol groups are the toxic feature.

We found out that these silanol groups are somehow effective, somehow causing the toxicity of the particle although it is not that clear whether these groups are simply the toxic feature or if it is contributing to some other features as well. If you compare it to Min-U-Sil we could see that for example epithelial cells were more prone to be harmed by the Min-U-Sil than our particles. We therefore know that there is a different mechanism of activity there, then in macrophages and this shows that the toxicity of particles is going to be more difficult to assess because there's going to be more parameters contributing to the toxicity of the particles, but we don't know which ones they are. The uptake was very interesting, for example different levels of concentration of silanol groups on the surface caused a different uptake. For example, if we had high concentrations of silanol groups those particles entered the cell but if reduced the silanol group concentration they would stay on the surface. These particles would cause toxicity, but they would cause toxicity not through phagocytosis but through some other mechanisms which we don't understand yet.

The most important thing is the future perspectives. What I think is the necessary thing to do is to appropriately and in detail characterise the silica particles to find out what, and this relates to dust as well, to find out what the toxic features of the particles are. We must develop a standardized and well characterized silica model which can be used in biological models which can be replicated and followed on. Additionally, we need to identify the mechanisms contributing or leading to susceptibility to TB and look at the chronic picture of silica and what it does throughout the time in the lungs and how it's affecting the person affected by silica particles.

Investigating the link between silica exposure and TB

Dr Shahieda Adams

I'm going to be speaking about TB risk and silica exposure. Despite us being a non-mining province, I run the occupational medicine clinic at Groote Schuur and every week we see one or two ex-mine workers with lung disease related to silica exposures so it's very much a topical issue. So, I thought I'd focus a little on silica exposure and health, so we know that the Health outcomes, the important ones are silicosis, silico TB (where you have a combination of both silicosis and tuberculosis disease affecting the lung), lung cancer and TB even when there is no evidence of radiological silicosis. Even with a normal, clear X-ray, these mineworkers are at high risk of developing TB for some reason. Silicosis is the more common picture we see in most of the ex-mine workers and we see all those little dots there on the X-ray, the nodules, and that is very classical of silicosis which is an irreversible fibrotic scarring of the lungs with a significant lung function impairment and impact on quality of life. Silicosis as we've heard is also a very strong predictor of recurrent TB.

A little bit about compensation law on TB is that it's covered by a very old law called the Occupational Diseases Mines and Works Act, it compensates TB in active mineworkers, i.e. if you get TB while working you'll be compensated, wage replacement, time off, etc. It also compensates for TB if the disease is contracted one year after cessation of employment. That is where the problem comes in because the mine worker's we see have left the mines 10 or 15 years ago and they're still getting TB. The act also allows for bi-annual surveillance which means that these mine workers can in fact present at a hospital for an examination to see if they have developed silicosis or diseases linked to silica exposure and it allows for autopsy of any mine worker irrespective of the cause of death and possible compensation. So even if you've died from a stroke and they do an autopsy and see silica particles in your lungs then you are eligible for compensation. The problem of course is that it's done at the National Institute of Occupational Health which is in Johannesburg and if you're a mine worker in the Eastern Cape or Limpopo, etc. or the labour sending areas, these people do not know about it or the logistics of getting heart and lungs to the NIOH is a big problem. Consequently, a fair number of mineworkers never access this unless they are aware of their rights.

TB is a multifactorial disease, there are many risk factors which operate, there's obviously the microorganism, there is HIV infection (we know that people who are HIV infected are at far greater risk), there is smoking , housing overcrowding , poor nutrition, social factors that impact and then there's the actual silica exposure, as well as the close proximity of large groups of fellow workers and working in very poorly ventilated settings as we've heard from speakers previously. The prevalence of latent TB infection in mineworkers is about 89%, so that is inactive TB, that is just having the germ, you're not sick with it, you don't need to go onto treatment, however you do face the risk of contracting active TB where you move from latent TB to active TB where you are actually sick with TB. 9 out of 10 of us already have the germ in the Western Cape and KZN and we expect it's very similar for mine worker's as well. Very high rates of HIV infection also put an added risk on to mine workers. The incidents for mine workers for TB have been assessed at about 3 per hundred-person years and in the general population it's just under 1, so mine workers have about a threefold higher risk of contracting TB than the general population. You can see very high rates of pulmonary TB in those that are HIV positive and very high rates of drug-resistant TB as well. These are just from studies done on active gold miners.

The other area that I've gotten involved in is that we were asked by some of the lawyers involved in the litigation to look at the case, making a case for compensating TB in mineworkers beyond the one-year post employment period. We think that the law is incorrect, and we think that because the silica particle is in fact retained in the lungs there is an enduring risk even after they leave employment and even if they don't actually have changes of silicosis on the X-ray, how do you make the case for it. We discovered that we had lots of questions but very limited evidence, and we know that eligibility for compensation by the current law is constrained by the fact that they only really get compensated if they develop TB within the first year. The problems were the persistence of TB risk in silica exposed workers, how do you diagnose TB retrospectively and how do you attribute risk to occupation exposure vs all the other factors mentioned that also modifies TB risk and the whole issue of legal reform to the Odimwa statute and the current compensation law.

The first question was does TB risk continue with cessation of exposure? There is one landmark study by Hnizdo and Murray, and it was a cohort study of white gold miners and of the 150 diagnosed with pulmonary TB the diagnosis was made on average 8 years after the end of exposure to dust. That's quite a long period after exposure and at around 60 years of age. What is important about this study is that it was done on white men with relatively low TB background rates and effectively no or very little HIV infection, so if there is an interaction between silica and HIV as there is for workers with actual silicosis and TB, the incident rates for black mine workers is likely to be a lot higher. In the Hnizdo and Murray study 15 of the 150 develop TB before they seized exposure, 6 at the time when they stopped working and 99 post cessations of exposure. The bulk of them developed it after being exposed. TB in those without radiological silicosis came to about a rate of 106 per hundred thousand however because we don't have TB rates to compare with those who were not exposed to silica dust at the time for white men, we don't actually know if this is elevated or not, we can't say.

The other question was what happens to risk over time and the other risk factors for which there is again very sparse data and more questions than answers but some of the questions are: is TB risk in ex-miners driven by silica retained in the lung or the other risk factors and then how do you attribute risk to the occupational exposure? After an initial episode of TB, the current practice is that mine workers be treated and then go back to the mines but is that the right thing to do? Is it right to return them to underground work after they've had TB? Are we not placing them at a greater risk having a recurrent bout of TB? We don't know. Is ongoing exposure to silica associated with increased risk for recurrent TB? Certainly, in our ex-mine worker's we've seen people that have had TB twice or thrice in their lifetime after leaving the mines. Are they at higher rates of recurrence and then also when in the employment time do mine workers get TB? There are some preliminary studies that suggest they get TB early on, but we don't know. We also see lots of TB in ex-mine workers, so the TB attack rate in young and old miners, we don't know. From some of the studies we know that in Basotho ex-mine workers (two to three years out of service) the rate is still 3 per hundred-person years which is still 3 times the average for the South African population and I've already spoken about the rates in the white mining cohort. Just to say that there's never really been a long-term follow-up study of black miners after they've left the mining service to look at some of these factors which is really what's needed.

Question 3: Is TB risk related to cumulative exposure or to intensity of exposure to silica and after CK’s presentation I suppose we also need to ask about the physicochemical properties of the dust and characterizing the exposure does that also play a role. There's very limited data on exposure intensity, despite regular monitoring of dust levels which is mandatory for the mines, but that data doesn't seem to be in the public domain and we don’t know what the quality of the data is or what the quality of the measurements are. There has been one Iranian study the show increasing risk for TB with increasing intensity of exposure. It's very difficult to tease out duration of exposure and intensity of exposure and it's not well studied. Currently just to say that in terms of the law, miners need to have had 200 risk shifts which is roughly 9 months of underground work to be eligible for compensation. Also, in COIDA, that's a different statute that covers people outside of the mining industry that might also be exposed to silica, you need to have only two years of exposure. Then you would be considered throughout your life if you had 2 years of exposure and developed TB.

We were also asked to grapple with the problem of retrospective diagnosis of pulmonary TB in silica exposed miners because there is a possibility that they would be included in the settlement. In terms of how you go back and verify that somebody infected have TB and was potentially related to their exposure. It was about how to evaluate and weight the evidence for a TB episode. The approach clinically would be to look at history and although that is very subjective it's about asking your patients whether they have had treatment for TB. There are many epidemiological studies done that does show that in fact having had an episode TB prior does translate to a greater degree of lung function impairment or more COPD (chronic obstructive lung disease) so it does relate to health impairment. Radiology, nonspecific but things like cavities for example would be correlated with TB exposure. We know that TB causes a lot of lung function impairment and then documentary evidence would obviously be like a gold stamp. If somebody can show your clinic card and show that they've received treatment there's no contest, he’s had an episode of TB 5 years ago or whatever. We revised the proposed criteria for retrospective diagnosis of pulmonary TB where we said category 1: where they had a past which is suggestive of TB history. We felt that there's a 60% chance that they probably did have TB. Category 2: where they had both a history and an evidence of post TB sequelae as evidenced by radiological as parametric findings, lung function impairment. Lastly, category 3: where they actually had objective evidence like a clinic card, sputum positive tests or something but you can actually see that we fell translated to 100% risk of having had TB.

Additional clinical questions, a little bit different from the others but what are the sequelae for mine workers with TB in terms of quality of life, health outcomes and social security (something we grapple with at the clinic) because the financial burden essentially gets externalized onto the public health sector who must do these examinations. Also, the Social Security Agency because many of them are unable to work so they end up having to access social grants in the form of disability grants. Then you know as clinicians we also grapple with the predictive value of all the tests we're doing. For instance, in the mines we do lots of chest X-rays, but we don't really know what the predictive value is, if there are changes of TB, are there at greater risk of more TB? We don't know. In summary data on exposure is needed, we must have adequate information on confounders such as HIV, socio-economic status, etc. We need better evaluations of the association between TB risk over time and accurate exposure data. We need to do research and studies that would inform on optimum screening strategies for TB detection in high risk populations such as mine workers. We definitely need to look at the health impacts and quality of life issues which I think are very big for mine workers.

Engineering tailings facilities for reduced dust emissions in South Africa

Fanus van Wyk

I'm going to talk about the engineering knowledge gaps that I think we are facing and I really think that unless we address those we can do on paper and in law whatever we want but we are still going to have the problems with regards to what we see on mine dumps. In my younger days I was responsible for more than 250 dumps in terms of dust mitigation and I had a lot of things to think about. Conventionally just grassing these dumps was the best way to deal with dust but as we've learnt over time there are a number of issues around grassing of dumps regarding re-mining and other issues that shapes the mindset of how engineers think about dust mitigation on these dumps. Consequently, I had to sort this out very early on. The mine dump as an obstacle in the landscape is almost like an airplanes wing: how air flows across, how it pushes up your airwaves and areas of high and low air pressure. This is one of the things I had to think of when we started off and then I had to deal with very small things. Having coarse material on the outside perimeter of a mine dump and very fine material on the inner of a mine dump and they behave completely different than soils. They are very flat, they're disc shaped, their longitudinal and latitudinal direction of access is very different. How do we model this? Can we model them like soils?

Basically, two things that I'm going to talk about is the current mindset around engineering and tailings dams. I'm going to use a bit of hindsight as to how we now approach solving the dust problem on a mine site. Secondly, what I consider how we should improve the design of mine dumps going forward specifically related to all the nice models that we have and going into the digital era.

The big issue is that we have a wonderful history of mining in South Africa going back more than 100 years but culture shapes process and if that culture is ingrained it is very difficult to change it. This is true for how we build, operate and design a mine dump. Engineers are the decision makers on the ground as to how the dump is built, how it is designed and how it is operated. The engineer's bible is code 10286, and he/she doesn't really bother about air quality acts and all that. The engineer wants a stable dam that is not going to fall over and also sees a mine dump as nothing else than a mineral stockpile that needs to be beneficiated over time and now we require him to cap and grass and do other things which is a problem for him/her. The engineer needs to focus on production - rand per tons and all that - so the design is minimalistic, but as a consequence, it is designed almost to blow away. The engineer thinks about stability, freeboard, he/she thinks about limiting pollution to a certain extent but that's not their biggest problem. Then with the 1998 to 2008 commodity slump we had a problem where most of the mines were not going to get closure for grassing these dams, so they didn't really bother about putting massive amounts of money into it because there was so much uncertainty. At this stage concurrent covers are still gospel for how to permanently cap these dams but very few of this is done because there's simply no money to do it and I see that the current dust mitigation tactic Is really perception management or emotion management. Being compliant and give dust monitoring results through but despite the fact that we're very legalized at the moment we haven't seen massive improvements in reducing dust from mines. I'm not bad-mouthing mines. They are my customers. They are my friends, but this is simply the fact of the matter. When you put massive amounts of money with limited information as to the efficiency of the intervention and follow the guidebook for engineers you end up with this perfect storm of how to create a perfect dust storm: we build dams as square as possible, we build them as steep as possible, maximum angle of repose, we build them as high as possible for maximum volume. We build them as coarse as possible on the outside to be very stable and as fine as possible on the inside because that is where the jelly has to sit and water needs to be retained. We build them as dry as possible, especially recently with cyclone technology, because we are water constrained but if we build them dry they are going to blow away. We unfortunately build them as cheaply as possible because it is about rand per ton and these rand per ton allowances to build these dams and dust mitigation is not necessarily top priority when we design these dams. Remember we've designed them for 20 30 40 years and we don't know what laws are going to be implemented in the future. Most of these dams have been designed in the 60s and 70s and they are not designed to contend with current mitigation so everything we are doing now is basically hindsight. Looking and dealing with problems of what is legacy issues. We also create berms where most or a lot of the dust envelope ends up. We drive on these because that's how we access the dams.

Work that I've done specifically relating to the previous points that I've mentioned before is that we are sitting with this amplification effect. Work done by Professor Blight suggests that the probability of dust coming off the top of dams is actually very low. However, the most recent work that we've been doing shows that there is actually a very high probability of dust being created and the dust can be created anywhere on a dump, so you cannot say that there are areas that are actually not prone to dust creation. The Ergo dump ground profile shows a dam 100 m high which is almost just at the bottom of where your wind turbines would generate maximum wind and you would expect dust to be generated from here. One of the problems is that the higher you go the more the vegetation struggles because the wind dries out that profile. As a practitioner I need to grass something up there which is virtually impossible. It is very difficult to stop dust from these areas which are very high and very steep. There are 7 main ways in which we build mine dumps: paddock, cyclone, spigot, spray-bar, open-ended, pasted and dry-stacked. Each of them behaves differently when we put them in a wind tunnel. The materials are different, they bind differently, they vegetate differently. We use two different models, the revised wind erosion equation (RWEQ)and Pasak to model where the dust comes from and to formulate our emission factors. These models show that different dams behave differently. This is important because we can focus on specific areas of the dam where the most dust will be generated and therefore there is a cost benefit for somebody who has to do something about this massive dump that just blows all over the place.

So how do we solve it? On a specific slope area, you can see that we calculated losses at about 130 tons per hectare per year loss and if we put some sort of a cover on it to create shear resistance we can bring it down to about 2 tons per hectare per year. The fact remains that you are going to still loose quite a bit of dust from these dumps. A more advanced approach that we take is to use CFD modelling to determine which areas are going to be producing most of the dust. This allows us to focus our attention on those areas. Going forward it's going to be critical for us to start to consider digital solutions and to build 3D models of the dams in the field. When we design new dams, we can now with proper information demonstrate how this thing will behave overtime. It is critical in future that government would ask this of a dump and of a design, especially with communities living around these dumps. This will show how this dam is going to behave and on the back of that a permit should be granted. This is what I've seen being done in other parts of the world. We are building dams completely differently than other countries. We are building dams high above the ground surface, but we can't continue to do that if we are creating these massive dust problems. Unless we influence the engineers, we are just putting a plaster on by just continuing to irrigate and grassing. We need to change the landscapes, we need to reconsider where we position these dumps and then we must consider real time monitoring, real time modelling and build these digital twins going forward. From a monitoring perspective it's important that we need to find a way to standardise source to surface area and distance to monitor. Unless we have those three things it becomes difficult to have consistent information about how a landscape behaves and then it is difficult to design these dams.

Implications of the revised National Dust Control Regulations (May 2018) and unresolved dust issues

Prof Harold Annegarn

Analogous to the referee in a soccer match dust monitoring plays the role of referee, it neither deals with the toxicity or the effects, it doesn't necessarily get into the complexities of the law. What it does is measure and say this is what it found. It doesn't deal with the strategy of how you play the game, whether you do the minimalist approach or a comprehensive approach. On the part of the mining company it just says: this is how we measure it. You've been provided with a very nice framework of what law is and what's being asked of you today is to do an analysis of the draft national dust regulations which were published in May after a two-and-a-half-year consultation process. In what way have these regulations changed from what went before. There have been several workshops, very comprehensive and engaged interactions from the Department of Environment and I must congratulate them and the outcome. I'm going to compare in this highly technical lecture the old and newly drafted regulations. I've included ready for reference the complete side by side comparison of the two texts so that this can become a source document.

The final proposal has already gone through two or three rounds of public consultation, so barring minor spelling corrections, the current draft regulations are likely to be what comes into force. I've done a side by side comparison highlighting the existing and the new text whether additions or deletions. The most important outcome of this very detailed interaction is that the DEA has decided to stay with the American standard test method for the determination of dust fall, ASTM D1739 with the important difference that the most recent version is used. In terms of the procedures ASTM standards are re-validated every 5 years even if there is no change. Our regulations makes reference to the latest version, whatever it is, so we don't again get caught in a time warp where we are using the 1970 standard because that wasn't in the regulation but in practice the 1998 revision had made substantial technical changes and we had essentially an unavailable standard that we were using then the newer more modern standard which had different methods. That is the most important change and I will look at some of the implications of that. The consequences of this I want to look at including changes to the apparatus, bucket size and shape, wet dry procedures each of which were points of contention. and Fanus in his closing remarks made some reference to sampling locations and that is one instance where I will make a further comment of discussion. Our existing method introduced in about 1985 originally applied around the coal fronting yards of Port Elizabeth of Clive Turner and of Eskom and implemented at Rand Mines Limited from about 1985 onwards monitoring around the recovering of gold mine tailings. Notice it has a bird ring but no windshield and the shape of the bucket was just a convenient available plastic paint bucket which we had moulded with an ultraviolet protective component but essentially didn't have the right diameter to depth ratio as specified. This is a matter of cost as it is extremely expensive to make a mould but relatively cheap to produce plastic components.

The major change from the 98 version is an introduction of a windshield. Notice that the shield has the leading edge at the top parallel with the top of the container and slopes inwards to deflect the wind downwards. This is the major requirement and presumably it is done to alter the efficiency to trap settleable dust. In the old method without the shield the turbulent flow that occurs over the bucket essentially creates a lid of lifting air over the bucket and at high wind speeds it is a very inefficient device. With the windshield the incoming wind is deflected downwards against the field resulting in a slightly better laminar flow over the top of the bucket. This results in a better chance of a uniform settling into the bucket irrespective of the wind speed. About 90% of the existing networks across the country still use the old method.

If we are going to change the sampling stands, which we will have to do we should also then change the container consisting of an open top cylinder not less than 150 millimetres. It doesn't say exactly, it says not less than and that gives a certain latitude. Regarding the dry/wet sampling issue, the new standard doesn't require putting water and biocide in the bucket which is great from a practical point of view. However, the experience in South Africa if it does rain and you get algal growth, it tends to clog the filter and you get a much higher sample loss. It is uncertain how this is to be resolved. It is no use just putting it out dry and then you find that you can’t filter 20% or 30% of your samples in summer because the algal mat forms such a gel that you can't pull it through a filter. This is an anomaly that's not resolved in the new regulations.

Regarding the number and location of the sites, the standard says for each region to be surveyed a minimum of four sampling sites and an orderly spacing of the stations should be made approximately at the vertices of an equilateral triangle grid. It is suggested that the spacing between sites should be between 5 and 8 km but at these distances the impact of the mine dust is lost in the background. Fortunately, this is a suggestion that doesn't have to be adhered to and in our own experience from practical monitoring shows 3 km is about the maximum distance that you're going to get a measurable impact from a mine tailings operation, even on the mega dumps. The draft regulations set the establishment of a network of dust monitoring points sufficient in number to establish the contribution of the person to dust fall in residential and non-residential areas in the vicinity of the premises to monitor identified or likely receptor locations. This is a critically important point that you are not monitoring at the boundary of the site. Instead, you are sensibly advised to go where there is a problem. Where there is a complaint about dust, let's put up a monitor. Where we have a large open grassland or degraded mine land with nobody living there, there is no pressure there. The purpose of monitoring sensitive or likely sensitive points is a different purpose of monitoring from what is necessary for validation of the design models which would work better if we had a regularly spaced grid at 500m intervals or in concentric circle points around your dump. Different purposes, regulatory compliance, and identification of welfare (which is very difficult to determine). In terms of mine dust I've got a very good indicator from 30 years of monitoring what dust welfare is and above 3000 to 4000 mg/m^3 /day is the point at which people start jumping up and down and contact the MPs or knock on the mine managers door. This is what informed the current standard of well below a 1000 mg/m^3 /day.

The sampling period the ASTM standard allows for is a calendar month plus or minus 2 days, and this implication means that it could be a month of 28 29 30 or 31 days plus or minus 2. In other words, it is not exactly 30 days plus or minus 2 days as it has been interpreted by some practitioners and if you're outside 30 ± 2 then your sample is not valid because you haven't complied with the standard. The issue is that the 10% variation of one extra day from 28 days to 31 days is not material in affecting the quality of data. In practice when we have weekends and public holidays which make it costly and logistically difficult to sample exactly within 30 or 32 days it will not invalidate your sample.

The limit values remain unaltered. There is a lot of discussion of whether the wind shield changes the efficiency and I believe it does. However, in the 4 or 5 side-by-side experiments that have been done, all have been poor quality including my own. The testing has been totally inadequate to establish any norm, so the department has got on there. This comes back to this legal question - this measurement of dust fall is an indicator, it is not an evaluation of toxicity, it is not a health based indicator, it doesn't presume that the chemical composition of the silica that is more or less toxic than any other form of dust, it is an indicator and that if it is dusty it requires control measures and mitigation. Too much dust is bad and don't try and make it so complicated and expensive that you can't have the referee on the field. There is only one referee, you can't have a referee on the field to monitor each player. There is also a minor change with the requirement that D had to be greater than 600 which was a slight illogicality.

The important points of principle here which is addressed also to people in public health, practitioners and to activists who have criticized this method. This ASTM standard deals only with methods of monitoring and analysis and contains no limit values. This is not about what is good for the environment or good for health. All it says is that if you want to know what the dust fall is as an indicator, this is a consistent practical way of measuring it. The method contains no presumption on the purposes of sampling whether scientific investigation, the regulatory compliance, health or nuisance effects, chemical contamination with regards to lead or radioactivity for example. These matters are best left to local or national jurisdictions such as our Department of Environmental Affairs Air Quality regulations such as our National Dust Control regulations. We have a context and we decide politically what is acceptable in our society at this time and within our budgets. The practical monitoring and analysis standard is not intended to address those things and people that criticize the standard that it doesn't address uranium, it doesn't address silica, it doesn't address the co-factors of silica and TB are totally missing the point. Irrespective of all those different purposes you still need a precise well-defined way of placing your samplers, how to measure, how to sample and how to analyse. Those people who criticize the standard for what it is not are basically failing to understand the purpose of a technical monitoring standard. It's not to say that there shouldn't be additional regulations to address these other issues but don't try and make it such an omnibus thing that you confuse the purpose of this type of standard with all the other desirable things. This standard is not going to cure HIV/AIDS for instance, it's not going to cure TB, so don't criticize it because it doesn't do those things.

There is a new regulation that places an obligation on mines and other listed activities that generate dust to implement dust emission management plans, so we don't have to wait for somebody to complain or an air quality officer to say that they must have a dust management plan. This is a practical, sensible thing that if you are operating a minerals processing plant and you are going to make dust, you are now automatically required to have a dust management plan. It tightens up on the reporting, so it requires a first report within 3 months rather than some unspecified time and it requires a report to be submitted monthly rather than annually. You must prove that you are using approved methods and request that where available you compare results to the previous 4 years. In other words, you don't look at just this year's dust fall, you look at historical records and you read it in the context of interannual change. You know that there is a seasonal cycle between dry and wet seasons but there are also windy and less windy periods. The new regulation 14 sets this requirement on the mines rather more stringently which is essentially a duplication. The rather strange new regulation 17 requires implemented dust management plans to provide proof in the reports that the plan has been implemented. What sort of proof they want? Certification and certification by whom? I would have thought that the report itself and data therein would be the proof.

Critical transitional arrangements set the date of rescinding the current regulations and setting the new regulations at the 1st of November 2019. You can change before that to the new method but by the 1st of November the new method should be in place. I think that one year is an adequate time for consultants and companies and newly affected parties to come into compliance. It is a very practical sensible time period, simply put without getting complicated phase overs.

That is the essence of the difference that indicated the full side by side comparison of the old and new method, but you see that they haven't gone to a radical new sampling method and I don't believe there is one. It is an indicator type monitoring, it is not health protective, it's not treating particles differently from one another because as we have seen from several of the presentations different dust have got different properties and it is not intended to do elaborate analyses. You can do microscopic individual particle analysis. This is an indicator measurement that is practical and can be maintained continuously year in and year out. I have been monitoring dust fall around Crown Mines from 85 continuously to the present. You can't be doing complex single particle analysis on every sample on every day. However, there are things that are missing from the standard that need to be addressed such as the efficiency of the sampler as a function of wind speed, it does not address issues of horizontal dust flux and soiling by the red dust from the Saldanha Bay ore loading facility and a similar problem with black dust at the Richards Bay coal terminal. Strong coastal winds with high moisture makes the dust sticky so wherever the horizontal dust flows, colours the surface.

You could ask the question what is happening elsewhere in the world and the only other country that actually got legislated requirements on such large-scale monitoring is Australia. The Australian dust sampling method has a much narrower tube which I believe is so narrow that it is highly inefficient at trapping dust but otherwise fairly similar to what we are doing. Reference is given to the Australian standard for those that are interested in it.

There are situations of amenity and well-being which are not addressed by putting a fixed bucket sampler if you have a problem with dust going into your buildings. For example, if there was a mine next to your premises and there was dust blowing into the building. It is not practical to install a dust monitor and it would not work. In this case just simply taking a petri dish and placing it on a windowsill and leaving it there for a week or 2 to a month and analysing the dust that is collected. If you get 1 or 2 mm of dust in a month on a windowsill you know that you've got a dust problem. You can't say that it doesn't comply with the national dust control regulation. It is clear that there is a problem which has to be dealt with. Even a simple method like a petri dish can give you valid information. Don't rely on the dust standard as the sole arbiter of what you are allowed to do to indicate if the dust is causing a nuisance.

The British Standard specifies the use of a directional dust gauge which is not very effective or useful. It is directional sampler and I just put it there for historical reasons because apparently it is still available in the UK market. More promising is a sticky pad adapter developed at the University of East Anglia. It is basically a piece of shelve-it sticky paper put it back to front around a cylinder and exposing it for 1- 2 weeks as the wind blows onto the cylinder. The particles will impact on the surface and stick then you put it under a microscope or a reflectometer and you measure the degree of obscuration or cover on the dust. This gives you a qualitative or semi quantitative indicator of the effect of absorption or reflectivity of your white material. Because it can be analysed in sectors you can get a 15-degree scan and the effective area coverage can be plotted as a polar diagram that indicates the direction that the dust is coming from. This is a nice practical method of sampling, a relatively easy method of presenting data. You only need an inexpensive printer scanner to do this by putting your sample on a piece of foil, photograph it and you get a 2000 dot per inch full 3 colour image which you can then put into a standard particle analysing software to measure the obscuration.

This is a very good directional indicator of where the dust is coming from and it's possible to do just the basic obscuration or with a little bit of ingenuity to present it to an electron microscope. It also has a vertical deposition analysed in the same way which is not dissimilar to dust fall but a limit is that the sticky pad gets saturated, so you can't really leave it for a month without getting saturated.

The British do not have a standard method, but they talk about disamenity. It is a professional society guideline which they give for disamenity or nuisance with values indicated by Beaman & Kingsbury of what the qualitative results are of rural, suburban, urban, real summertime Industrial and noticeable, possible complaints, objectionable probable complaints, serious complaints. It is an indicator that many environmental problems can be solved not by litigation, not by going to lawyers but by practical engagements. By identifying a problem, determining who is causing it, and discussing ways in which you can mitigate, or do you need additional mitigation measures or did your mitigation fail, what went wrong. Most of the time just talking to people and finding out what is really concerning them, you can resolve most of these dust complaints by simple negotiation rather than huge monitoring campaigns and litigation.

Lastly some terminology, the term impact and effects are often used interchangeably. I suggest that impact is the concentration, the deposition rate, flux rate or pollutant or increment at some specific location. This is what monitoring does, it tells you what the impact is. What the health people are concerned with is what the effect is, the consequence of the impact whether it is lung impairment, enhanced TB, nuisance, material damage, reduced crop productivity, loss of amenity is the effect. For our own use and for our students we should try to adopt a uniform terminology. We distinguish between an impact which is what a monitoring process does or what a consultant does and the effects which a public health department or the provincial regulators will deal with. These are two separate things and distinguishing the terminology would reduce a lot of noise in our debate.

My acknowledgements: to ERGO Gold for permission to use the results; my acknowledgements to Eskom for supporting the chair of Atmospheric Science and Monitoring at North West University with which I'm affiliated. I declare an interest that I'm a consultant and have been to ERGO and its predecessors and still currently am paid by a mining company to advise them on dust monitoring.