Shifting Challenges of Air Quality in South Africa

AIR QUALITY WEEK 2015

1 - 2 OCTOBER I BLOEMFONTEIN

Annual Conference Proceedings

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Shifting Challenges of Air Quality in South Africa

PROCEEDINGS OF THE 2015 CONFERENCE OF THE NATIONAL ASSOCIATION FOR CLEAN AIR

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WELCOME MESSAGE

Dear Colleagues and Members of the South African Air Quality Fraternity
It is my privilege and great pleasure to welcome you, on behalf of the organising committee, to Bloemfontein for the 2015 NACA conference. The theme for this year's conference is "Shifting Challenges of Air Quality in South Africa".

Since NACA started in 1968, the Air Quality landscape in South Africa has shifted significantly. The national priorities have changed and the focus of national legislation and air quality management has adjusted to meet the social and environmental imperatives that have been set. It is the role of air quality managers and researchers to guide us in meeting the shifting challenges and grasp the emerging opportunities to protect and improve the quality of air to which our fellow citizens are exposed.

NACA as an organisation has an important function in promoting the cause for clean air in South Africa. Through our constitution we are obligated to play a role in the accumulation and dissemination of air pollution information. This is done through our regular seminars, the Clean Air Journal and this conference. In addition, the role of NACA is to act as a channel through which public and industrial opinions concerning air pollution can be communicated to regulatory authorities. I would therefore like to welcome the participants from industry, from the regulatory authorities and from NGOs. Thank you for helping us fulfil our mandate and I hope that you take the opportunity to share information and ideas, to build relationships and to identify new opportunities to better understand and address the shifting challenges of air quality in South Africa.

We have been very fortunate that there has been a massive interest in this year's conference, over 60 abstracts were submitted. Through our strict peer review process, 30 papers were selected for oral presentations and several abstracts were selected for the poster sessions. I therefore ask all participants to engage with the posters and discuss the science being presented.

It is through our collective engagement with the science that is being conducted and the knowledge that is being generated that we can develop the tools to address the shifting challenges in air quality in South Africa.

Dr Gregor Feig
President
National Association for Clean Air

COMMITTEES

The organising committee would like to thank all those who gave their time and effort in the various aspects of the conference organisations.

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Roelof Burger
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Papers submitted for oral and poster presentation were subject to a scientific review process by two reviewers. The National Association for Clean Air wishes to thank the review committee for their efforts and time:

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2015 NACA NATIONAL CONFERENCE PROGRAMME

1 - 2 OCTOBER 2015
President Hotel, Bloemfontein, Free State, South Africa

Wednesday, 30 September 2015

08:00 - 17:00	NACA Registration
09:30 – 12:45	**Department of Environmental Affairs, launch of the South African Atmospheric Emission Licensing and Inventory Portal** (SAAELIP)
12:45 - 14:00	*Lunch*
14:00 - 17:00	**Workshop on the International and National Landscape of Atmospheric Mercury hosted by the Laboratory for Atmospheric Studies.** Sponsored by the University of Pretoria, North-West University, SASOL, Eskom and NACA
17:30 - Late	**ICE-BREAKER COCKTAIL** President Hotel, Pool Area (Lower ground floor)

Thursday, 1 October 2015

07:30 - 08:30	*Registration & Refreshments* **Session Chair:** Dr Gregor Feig
08:30 - 08:40	**Welcome by NACA President** Dr Gregor Feig
08:40 - 09:00	**Feedback from DEA Lekgotla** Dr Thulie Mdluli, Chief Director: Air Quality Management
09:00 - 09:05	**Introduction to keynote speaker** Dr Gregor Feig
09:05 - 09:45	**Mercury in the environment: Past problems, current status and future challenges** Dr Ian Hedgecock, CNR-Institute of Atmospheric Pollution Research, Italy
09:45 - 10:05	**Domestic Fuel Burning Emission Reduction: Eskom's Kwazamokuhle Pilot Study** Kristy Langerman
10:05 - 10:25	**Exploring Cross-Sectional Study Design in the Study of Indoor Fuel Combustion and Respiratory Health Outcomes** Caradee Wright
10:25 – 11:00	*Mid-morning Refreshments - Exhibition and Poster Viewing*

2015 NACA NATIONAL CONFERENCE PROGRAMME (continued)

Thursday, 1 October 2015 continued

	SESSION 1A – Main Plenary
11:00 - 11:20	**Simulating Fine Resolution Winds in South Africa using Different Global Forcing Fields** Hannes Rautenbach
11:20 - 11:40	**Multi-Year Analysis of Aerosol Optical Depth and its Impact on Cloud Properties over Cape Town as Retrieved from Modis** Joseph A. Adesina
11:40 - 12:00	**Gaseous Elemental Mercury (Gem) at Cape Point – A Statistical Investigation** Andrew Venter
12:00 - 12:20	**Indoor and Ambient Particulate Matter Exposure on the Mpumalanga Highveld - A Case Study** Bianca Wernecke
	SESSION 1B – Breakaway Venue
11:00 - 11:20	**Air Pollutant Emissions Inventory from the Development, Production, and Processing of Unconventional Gas in the Karoo Basin, South Africa** Katye Altieri
11:20 - 11:40	**Atmospheric Emissions from Clamp Kilns in the South African Clay Brick Industry** Oladapo Akinshipe
11:40 - 12:00	**Automated Monitoring System (AMS) Calibration Principles - EN14181:2014** Gerald Woollatt
12:00 - 12:20	**Fuel from Invader Species for Domestic Gasification Stoves: Processing and Emission Factors** Gerrit Kornelius
12:20 - 13:20	*Lunch*
13:20 - 13:40	**Spray Drying for the Simultaneous Removal of SO2 and NOx from Flue Gas – Experimental Results** Brian Little
13:40 - 14:00	**Estimation of Exhaust Emission from Ocean-going Vessels for the Port of Cape Town** Farryn Moodley
14:00 - 14:20	**The Consideration of Non-anthropogenic Emissions for Air Quality Modelling in South Africa** Mogesh Naidoo
14:20 - 14:40	**Nighttime High Ground-level Ozone Concentrations in Southern Johannesburg** Cheledi Tshehla
14:40 - 15:00	**Development of High Accurate Propane (C3h8) Reference Gas Mixtures for Industrial and Stack Emission Measurements** Mudalo I. Nemadzhilili

Thursday, 1 October 2015 continued

15:00 - 15:30	*Poster Viewing and mid-afternoon break*
15:30 - 15:50	**Representation and Validation of Aerosol Particles in Regional Climate Modelling in Africa** Rebecca Garland
15:50 - 16:10	**Modelling Wet Flue Gas Desulfurisation** David Branken
16:10 - 16:30	**The Influence of Grid Resolution on WRF-ARW Wind Simulations for Elandsfontein, Mpumalanga, South Africa** Anesu Shamu
16:30 - 16:50	**Climate Change Impacts on Mean Wind Speeds in South Africa** Hannes Rautenbach
17:30 - 18:30	**NACA ANNUAL GENERAL MEETING** Venue: Plenary Venue
19:00 - Late	**NACA GALA DINNER** President Hotel

Friday, 2 October 2015

08:00 - 08:30	*Tea & Coffee*
08:30 - 08:50	**Correcting Respirable Photometric Particulate Measurements using a Gravimetric Sampling Method** Brigitte Language
08:50 - 09:10	**Improving Indoor Air Quality Monitoring Measurements using Hydrogen Sulphide Reference Gas Mixtures** Nompumelelo Leshabane
09:10 - 09:30	**Comparison of Different Dust Fallout Measurement Techniques with Specific Reference to the Standard ASTM 1739:1970 Technique for the Measurement of Dust Deposition in South Africa** Johannes Lotter
09:30 - 09:50	**Windshields vs No Windshields: A Comparison of Dustfall Rates** Jared Lodder
09:50 - 10:10	**A Comparison Between Dust Deposition Concentrations in Directional and Non-directional Dustfall Samplers** Martin van Nierop
10:10 - 10:30	*Mid-morning Refreshments - Exhibition and Poster Viewing*

2015 NACA NATIONAL CONFERENCE PROGRAMME (continued)

Friday, 2 October 2015 continued

10:30 - 10:50	**The use of Fine Water Sprays to Suppress Fume Emissions when Casting Refined Ferromanganese** Sarel Gates
10:50 - 11:10	**Emissions Management and Health Impacts: Are all Power Stations Equal?** Ilze Pretorius
11:10 - 11:30	**Geospatial Assessment of Air Pollution Risk as part of the Dr. KKDM AQMP** Elanie van Staden
11:30 - 11:50	**Identifying Mitigation Opportunities in Low Income Households** Jaun van Loggerenberg
11:50 - 12:10	**Influence of Coal-Particle Size on Emissions Using the Top-Lit Up-Draft Ignition Method** Lethukuthula Masondo
12:10 - 12:30	Awards for Best Papers Announcement of NACA 2016 **CLOSING**
12:30	*Lunch*

SCIENTIFIC PAPERS

MULTI-YEAR ANALYSIS OF AEROSOL OPTICAL DEPTH AND ITS IMPACT ON CLOUD PROPERTIES OVER CAPE TOWN AS RETRIEVED FROM MODIS

Joseph A. Adesina[1,2]*, Stuart J. Piketh[1], Raghavendra K. Kumar[3], and V. Sivakumar[2]

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Abstract

Aerosols, a significant component of air pollution may lead to an increase in cloud optical thickness due to a combination of reduction in cloud droplet radius and increased water content. Clouds that are formed in a polluted environment tend to have smaller droplets which can bring about suppression of precipitation and temporal variation in cloud life time. Aerosols indirect effect can inhibit cloud formation and evaporation of existing cloud so that aerosol-cloud interaction presents a major research area in atmospheric science. We have used the Terra Satellite onboard of the Moderate Resolution Imaging Spectroradiometer (MODIS) to investigate the temporal relationship between aerosol optical depth and cloud parameters namely, water vapor, cloud fraction and cloud effective radius. The correlation of aerosol optical depth with cloud effective radius and water vapor suggests that aerosols at this location do not significantly undergo hygroscopic growth. The correlation with cloud fraction also indicates that aerosol-cloud interaction might not lead to suppression of precipitation over the region.

Keywords: Aerosol optical depth, Cloud effective radius, Cloud fraction, Ångström exponent, HYSPLIT

SCIENTIFIC PAPERS (continued)

ATMOSPHERIC EMISSIONS FROM CLAMP KILNS IN THE SOUTH AFRICAN CLAY BRICK INDUSTRY

Oladapo Akinshipe*[1,2] and Gerrit Kornelius[1,2]

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Abstract
The quantification of atmospheric emissions from clamp kilns in the South African clay brick industry has met with limited success. The pyramid-shaped, complex configuration of clamp kilns using coal or other carbonaceous fuels, as well as the uncertainty regarding combustion conditions within the kiln, has proven to be a hurdle in the measurement of emission parameters associated with gaseous and particulate pollutants.

To facilitate the measurement of these parameters, a model kiln was designed to fire bricks at operating conditions and configuration similar to a transverse slice of a full-scale clamp kiln used for brick firing in South Africa, but with a lower production capacity. The model kiln design ensures adequate confinement, capture and extraction of flue gases from the firing process with the aid of a bifurcated fan forcing the draft through to an extraction stack where monitoring takes place. The design provides adequate spacing to cater for packing and unpacking of bricks, and provides sufficient air for the combustion process, while still ensuring minimum losses of flue gas via the semi-enclosed sides.

Seven firing cycle have been completed so far, each within a period of 10 to 14 days. Hourly readings are recorded for PM_{10}, SO_2, NOx, NO, NO_2, CO concentrations and process parameters in the extraction stack.

Preliminary emission rate results from the monitoring program range from $1.25 \times 10^{-1} – 2.45 \times 10^{0}$ g/s for CO, $5.00 \times 10^{-3} – 9.00 \times 10^{-3}$ g/s for NO, 0 g/s for NO_2, $5.00 \times 10^{-3} – 9.00 \times 10^{-3}$ g/s for NOx, $2.9 \times 10^{-2} – 8.50 \times 10^{-2}$ for SO_2 and $7.00 \times 10^{-3} – 1.40 \times 10^{-2}$ for PM_{10}.

Keywords: *Stack monitoring, clamp kiln, emission rate, emission factor, model kiln design, clay brick emissions.*

AIR POLLUTANT EMISSIONS INVENTORY FOR NO^x FROM THE DEVELOPMENT OF UNCONVENTIONAL NATURAL GAS WELLS IN THE KAROO BASIN, SOUTH AFRICA

Katye E. Altieri*[1], Adrian Stone[2]

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Abstract
Unconventional natural gas (shale gas) operations have the potential for larger environmental impacts than conventional gas operations. New wells are drilled regularly and operated continuously, which creates a constant output of pollutants from diesel generators, large non-road engines, and truck traffic. The Karoo basin is a sparsely populated and vast area, with low levels of industrial activity. There is currently no air quality management plan and no ambient air quality monitoring in place in the Karoo. Yet this region is underlain by a technically recoverable shale gas reserve estimated to be as large as 390 trillion cubic feet (TCF; U.S. EIA 2013, Decker, J.; Marot 2012), with 20 to 50 TCF recoverable over a 25 year time period. The development, production, and processing of unconventional natural gas has been a significant source of air pollution in other regions (e.g., Litovitz et al. 2013, Roy et al. 2014). The air pollutant emissions depend on local conditions, including the depth of the shale, distance between water sources and the wells, available water treatment options, total number of wells, distance between wells, locally available technology, and the experience level of the operators in the industry. An *in silico* bottom-up process-level emissions study was conducted to estimate nitrogen oxide (NO_x=NO+NO_2) emissions from major well development activities including drilling, hydraulic fracturing, and truck traffic. A Monte Carlo approach was used to develop distributions of emission estimates in order to account for the uncertainty in input data given that the exact number of wells and scale of the resource remain poorly constrained. It is critical that policymakers at all levels of government are provided with unbiased information and the necessary tools to safely monitor and regulate the potential environmental impacts of this new industry.

Keywords: *Emissions Inventory, Unconventional Natural Gas, Nitrogen Oxides, Karoo*

SCIENTIFIC PAPERS (continued)

MODELING WET FLUE GAS DESULFURIZATION

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Abstract
Eskom's new build power plants Kusile and Medupi will be fitted with wet flue gas desulfurization (WFGD) plants to meet compliance levels for SO_2 emissions. Although WFGD, as operated in Europe, is capable of achieving SO_2 removal efficiencies between 95 – 98 %, operation with South African limestones are yet to be characterized.

An investigation was therefore undertaken to develop an integrated reaction rate model for wet desulfurization, which is used as input in detailed Computational Fluid Dynamics (CFD) models of WFGD absorption towers that includes detailed gas and slurry droplet flow dynamics. A semi-batch laboratory reactor was used with industrial type flue gases and commercial grade limestones, and the results have been modeled to identify the important mechanisms and the associated parameters. At this preliminary stage, it would seem that the dissolution of limestone, which is heavily influenced by the solution pH, is the rate determining step in the formation of gypsum, i.e. the final byproduct of the WFGD process. The results from these kinetic studies are to be used in conjunction with detailed CFD modeling, from which more simplified process models can be derived. It is therefore envisioned to use such process models to evaluate the use of limestones of varying quality and to characterize cost/process efficiency tradeoffs. Furthermore, the availability of accurate process models will enable efficient operation and control of Eskom WFGD plants. This paper therefore focuses on the construction of relevant CFD models, of which some preliminary results are showcased.

The water consumption for WFGD is approximately 30% more than for conventional semi-dry FGD processes. Medupi Power Station which is situated in the semi-arid region of Lephalale in the Limpopo Province is to be retrofitted with a FGD plant approximately six years after the commissioning of each boiler unit. Water optimization for WFGD remains an important aspect and options to reduce water losses are discussed in this paper.

CR(VI) GENERATION DURING FLARING OF CO-RICH OFF-GAS FROM CLOSED FERROCHROMIUM SUBMERGED ARC FURNACES

Stephanus P. du Preez[1], Johan P. Beukes[1]*, Pieter G. van Zyl[1]

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Abstract

Although chemical oxidation states for chromium (Cr) range from -4 to +6, only Cr(III) and Cr(VI) are stable in the ambient environment (Mohan and Pittman 2006). Cr(III) is considered an essential micro-nutrient (Berner et al. 2004), while Cr(VI) is generally considered to be carcinogenic (Bielicka et al. 2005).

Cr(VI) can be generated and/or released into the environment through various anthropogenic activities, e.g. leather tanning, stainless steel welding and stainless steel production. Of relevance in this paper is the generation of Cr(VI) during ferrochrome (FeCr) production. FeCr is produced from chromite ore and is a relatively crude alloy that consists mainly of Cr and iron (Fe). FeCr is the only source of new Cr units used during stainless steel production. Stainless steel is a vital alloy in the modern society, making FeCr equally important.

Beukes et al. (2010) reviewed the generation of Cr(VI) during FeCr production. According to this paper and references therein, several ferrochrome production steps can lead to Cr(VI) formation (Beukes et al. 2010). This review also highlighted uncertainties with regard to certain production steps that need to be further investigated in order to enhance the current understanding of Cr(VI) generation during FeCr production. One such process is the flaring of CO-rich off-gas from closed submerged arc furnaces (SAF).

Off-gas from a closed FeCr SAF is usually cleaned with wet venturi scrubbing, which removes 99.9% of particulate matter in the off-gas, reducing particulate matter from 35-45g/Nm^3 to 50-100mg/Nm^3 (Niemelä et al. 2004).

Currently, almost no data exist in the peer-reviewed public domain to quantify the conversion of Cr(III). As far as the authors could assess, only a personal communication has been cited in an environmental impact assessment (EIA) (Venter and Liebenberg-Enslin, 2004), which indicated that approximately 0.8-1% of Cr(III) is converted to Cr(VI) during flaring. This conversion factor has since been used in various EIAs, although it is largely unverified since no supporting data were supplied in the afore-mentioned personal communication.

In order to partially address the uncertainty relating to Cr(III) to Cr(VI) conversion during flaring of CO-rich off-gas from closed FeCr SAFs, the influence of flaring temperature, size of the particles passing through the flare and retention time within the flame was investigated in this paper. Although the oxidation of Cr(III) to Cr(VI) depends on various factors, these three factors are likely to be important within this context. Multiple linear regression was also used to combine the effect of the three parameters investigated to estimate the overall impact.

SCIENTIFIC PAPERS (continued)

REPRESENTATION AND VALIDATION OF AEROSOL PARTICLES IN REGIONAL CLIMATE MODELLING IN AFRICA

Rebecca M. Garland[1,2,*], Hannah M. Horowitz[3], Marcus Thatcher[4], Mogesh Naidoo[1], Jacobus van der Merwe[1], Willem A Landman[1,5], and Francois A Engelbrecht[1,6]

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Abstract
Aerosol particles can have large impacts on air quality and on the climate system. A shifting challenge in air quality in South Africa is how to effectively consider the air quality and climate co-benefits when crafting policy. In order to analyse the impact of aerosol particles on climate, as well as the potential impacts of climate change on air quality, regional climate models and their outputs can be utilized. However, regional climate models for Africa have not been well-tested and validated for their representation and simulation of aerosol particles. This study aimed to validate the current representation of aerosol particles in the Conformal Cubic Atmospheric Model (CCAM), using the CMIP5 historical emissions inventory, to monitored data over Africa.

In this study, CCAM was used to produce historical regional climate model simulations at 50 km horizontal resolution, globally, through the dynamical downscaling of ERA Interim reanalysis data. CCAM has a prognostic aerosol scheme for organic carbon, black carbon, sulphate, and dust, and non-prognostic sea salt. The aerosol optical depth (AOD) at 550nm from CCAM was compared to the AOD values (observed at 440nm and adjusted to 550nm using the Ångström exponent) from AERONET stations across Africa for 1999-2012. For this validation with AERONET, sites that are strongly impacted by aerosols from natural sources were prioritized. In general, the model captures well the monthly trends of the AERONET data. This presentation will provide, through comparisons to monitored data, a basis for understanding how well aerosol particles are represented over Africa in regional climate modelling using the emissions inventory from the latest Intergovernmental Panel on Climate Change assessment report.

Keywords: *Aerosol particles, regional climate modelling, aerosol optical depth, natural aerosol emissions*

THE USE OF FINE WATER SPRAYS TO SUPPRESS FUME EMISSIONS WHEN CASTING REFINED FERROMANGANESE

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Abstract
During the casting of refined ferromanganese alloys from electric arc furnaces into sand beds at temperatures of up to 1800°C a considerable amount of very brown fumes is generated when the alloy fume is oxidized in the atmosphere. The fume is difficult to capture because of the large flux of gas that is generated. Possible reasons for this flux include the high evaporation rate of Mn at elevated temperatures, the large surface area of the casting beds and the large thermal plumes over the furnace tapholes and casting beds. It has been found that the use of fine water sprays along the edge of the roof that covers the casting bed resulted in a significant reduction in visible emissions. This paper describes research into the kinetics of the fume to improve the design of the capture hoods, as well as the mechanism of suppression by the water sprays by using CFD analysis. It is shown that the oxidation reaction produces less than 20% of the energy content of the plume over the arc furnace taphole, and also that radiation heat transfer may play an important role in increasing the energy content of the taphole plume. The capture of fume particles by fine spray droplets is shown to have limited efficiency, while the heat sink that is caused by evaporation does not materially contribute to the circulation of fume through the spray. It is surmised that the increased moisture content of the air over the casting beds may be instrumental in the formation of an oxide layer, which reduces metal evaporation and, therefore fume formation.

Keywords: *ferromanganese, secondary fume, water sprays, fume capture hoods, fume extraction, ferro-alloy tapping*

SCIENTIFIC PAPERS (continued)

CLIMATE CHANGE IMPACTS ON MEAN WIND SPEEDS IN SOUTH AFRICA

Lynette Herbst*[1,2] and Hannes Rautenbach[2]

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[2]Laboratory for Atmospheric Sciences, Department of Geography, Geoinformatics and Meteorology, University of Pretoria, hannes.rautenbach@up.ac.za

Abstract
Climate change could potentially affect a number of variables that impact the dispersal of and human exposure to air pollutants, as well as climate dependent sectors such as wind energy. This study attempted to quantify the projected changes in seasonal daily mean wind speeds for South Africa around the mid-21st century (2051-2075) under two different atmospheric heat pathways. Seasonal daily mean wind speed increases rarely reach 6% and decreases occur to a maximum of 3% and are variable between different seasons and areas within the country. In all seasons except December-January-February, wind speeds are projected to increase in the Highveld region, suggesting that air pollution dispersing conditions could increase. Wind direction at the 850hPa-level show minor changes, except over the Western and Eastern Cape provinces.

Keywords: *Climate change, wind speed, air pollution, mitigation, climate models.*

FUEL FROM INVADER SPECIES FOR DOMESTIC GASIFICATION STOVES: PROCESSING AND EMISSION FACTORS.

Gerrit Kornelius, Christelle de Jager and Phina George Kariyatty

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Abstract

Exposure to air pollutants resulting from the use of coal and wood in South African townships has been extensively reported on. Mitigation of exposure due to coal fires has received considerable attention, but little has been published on mitigation of exposure to smoke from wood burning. We have previously reported on the design and operation of a simple natural draft wood gasification stove that could play a role in this. The emission factors reported in previous work were obtained using a uniformly sized fuel to ensure reproducibility in laboratory work. In the present paper, we report on the processing of locally harvested wood from invader species, such as is produced by the Department of Environmental Affairs' Working for Water (WfW) programme. The fuel is produced using a commercial wood chipper followed by sun drying. Operating characteristics and emission factors for various size fractions are reported, the emission factors being obtained by the use of a dilution sampler similar to the UJ SeTAR apparatus with some simplifications. Emission factors for CO are much higher than those reported for the "ideal" uniformly sized fuel, but they are a factor of five or more lower than those reported for an open wood fire, while particulate matter emission factors are at least an order of magnitude lower than those reported for open fires. As the stove design is simple enough for manufacture by rural artisans, the use of wood from invader species potentially provides a market for the wood harvested by the Working for Water projects.

Keywords: *Domestic fires, emission factors, wood gasification stove*

SCIENTIFIC PAPERS (continued)

DOMESTIC FUEL BURNING EMISSION REDUCTION: ESKOM'S KWAZAMOKUHLE PILOT STUDY

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Abstract
Scientific studies show that in South Africa the main cause of harmful health effects due to poor air quality is the domestic burning of solid fuels, usually in dense, low income settlements. The reduction of emissions from domestic burning therefore needs to be addressed as an equally pressing priority in parallel to industrial point source emission reduction, in order to meaningfully improve the health and quality of life of people living in areas with poor air quality. Eskom, in partnership with the North-West University, the NOVA Institute, E-Science Associates, the CSIR and Prime Africa Consultants, have embarked on a pilot study in order to test the feasibility of several interventions intended to reduce emissions from domestic solid fuel burning. 140 households in KwaZamokuhle (near Hendrina in Mpumalanga) have been randomly selected to participate in the pilot study. Twenty households form the control group, and the interventions have been rolled out at the remainder. Each of the treatment houses has either been fitted with a ceiling or full thermal insulation, and then either supplied with a more efficient coal-burning stove, or an LPG heater and stove, or an electricity subsidy. Amounts of solid fuel used, indoor temperature and indoor air quality will be monitored, in addition to ambient air quality and personal exposure monitoring. Preliminary results show that around 74% of households burn coal as their main energy source. Domestic burning is the main contributor to ambient PM10 concentrations in summer and winter, and the main contributor to ambient SO_2 and NO_2 concentrations in winter. Reducing solid fuel burning emissions thus has the potential to reduce levels of all three criteria pollutants in low income settlements.

Keywords: domestic burning, air quality offsets

CORRECTING RESPIRABLE PHOTOMETRIC PARTICULATE MEASUREMENTS USING A GRAVIMETIC SAMPLING METHOD

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Abstract

According to the National Environmental Management: Air Quality Act of 2004 people have the right to clean air and a healthy environment. Particulate matter (PM) emissions pose a significant health threat. Both indoor and ambient air pollution contribute to the burden of disease associated with poor air quality. This is particularly true within the South African setting where low income households make use of different solid fuels for heating and cooking purposes resulting in high levels of PM emissions. This paper focuses on the evaluation of measured and derived mass concentration measurements recorded by continuous photometric PM instruments within KwaDela, a low income settlement in Mpumalanga located on the South African Highveld. Thus, obtaining a photometric calibration factor for both the DustTrak Model 8530 and the SidePak AM510. Sampling took place during August 2014 for a period of seven days. The photometric and gravimetric instruments were collocated within selected households. These instruments were all fitted with 10mm Dorr-Oliver Cyclone inlets to obtain the respirable (PM_4) cut-point. The study found that both instruments tend to overestimate the indoor particulate mass concentrations when compared to the reference gravimetric method. The estimated photometric calibration factors for the DustTrak Model 8530 and SidePak AM510 are 0.14 and 0.24 respectively. The photometric calibration factors assist in acquiring a more accurate representation of the actual PM_4 mass concentrations within an indoor environment prone to the combustion of solid fuels.

Keywords: *particulate matter, gravimetric analysis, light scattering photometer, photometric calibration factor; indoor air quality*

SCIENTIFIC PAPERS (continued)

IMPROVING INDOOR AIR QUALITY MONITORING MEASUREMENTS USING HYDROGEN SULPHIDE REFERENCE GAS MIXTURES

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Abstract

Hydrogen sulphide (H_2S) is one of the gases monitored by industries due to its toxic nature in human health. It depletes oxygen in air, thus inhibits oxygen from reaching vital organs such as the brain, causing dizziness in the process. H_2S is mainly monitored for occupational health and safety and indoor air quality. The gaseous breakdown products of sulphur containing compounds such as H_2S are generated under anaerobic conditions. Sulphur containing compounds are also present in high quantities in natural gases and emitted during volcanic eruptions.

Reference gas mixtures are gravimetrically prepared in accordance to International Organization for Standardization (ISO 6142). The H_2S reference gas mixtures used in this investigation were produced with the lowest metrological uncertainty level, thus the molar mass, purity assessment, and the weighing of each gas gave an overall gravimetric relative uncertainty which is less than 0.2 % (k=1).One of the biggest challenges in producing H_2S gas mixtures is the adsorption and desorption (stability) within the cylinder and hence reported uncertainty increases. This work details the study of adsorption and desorption effect of H_2S reference gas mixtures. The internal consistencies between the mixtures were verified using a Non-Dispersive Ultra-Violet analyser (NDUV).

Our measurement uncertainty results show that the gravimetric value, internal consistency, homogeneity and stability were within relative uncertainty of 0.5 % as compared to our previous uncertainty of 3%. This is a significant improvement for the measurements of air quality monitoring using H_2S reference gas mixtures.

Keywords: *Indoor air quality, hydrogen sulphide, reference gas mixtures, accurate, uncertainty*

SPRAY DRYING FOR THE SIMULTANEOUS REMOVAL OF SO2 AND NOx FROM FLUE GAS – EXPERIMENTAL RESULTS

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Abstract

The implementation of the "New plant" emission limit values set in terms of section 21 of the National Environmental Management - Air Quality Act requires the reduction of emissions from a number of smaller operations, especially in the metallurgical field. Although apparatus for the control of particulate matter for such smaller operations has traditionally been designed and manufactured locally, there is less local experience with the control of SO_2 and NO_x at small scale. In this paper, we report results from laboratory-scale work on the use of spray drying for simultaneous control of SO_2 and NO_x using suspensions of commercially available dolomitic lime. In a 3 m high spray column, up to 70% of SO_2 could be removed in the absence of NO_2; when both SO_2 and NO_2 were present, approximately 30% efficiency was achieved for both. The oxidation of NO to NO_2, which is required where the NO_x emissions are in the form of NO, was also investigated using ozone as the oxidant. Inconclusive experimental results were obtained, but sound literature data for the process design of this reaction exists.

Keywords: *SO_2 removal, NO_x removal, spray drying, NO oxidation.*

SCIENTIFIC PAPERS (continued)

WINDSHIELDS VS NO WINDSHIELDS: A COMPARISON OF DUSTFALL RATES

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Abstract
Fugitive dust occurs from a range of natural and anthropogenic sources. Fugitive dust has the ability to pollute the ambient environment and impact on surrounding areas. Monitoring of dustfall in South Africa has been on-going for decades. A number of methods exist to conduct dustfall monitoring; however, the predominant method has been the ASTM D1739. The SANS 1929 (2005) provided the guidelines for dustfall monitoring until the National Dust Control Regulations were promulgated in 2013. The introduction of the NDCR required the ASTM D1739 (1970) method to be used as its basis. This method does not include a windshield that was included in the later re-approved versions of the ASTM D1739 (1998). However, many facilities still made use of the dustfall samplers with a windshield. This study aimed to investigate the potential variation in dustfall deposition rates using co-located dustfall samplers with and without windshields. The study comprised of five sites that were monitored for one year. The co-located samplers were located within one meter of each other, at the same height and with water, to minimise variability. All samples were exposed from 30 days ± 2 days, gravimetrically analysed and expressed as a rate mg/m^2/day as per the ASTM D1739 (1970). The results from 53 paired samples, indicate a close correlation (R^2 = 0.876) with a slope of 0.934 between samples collected with and without a windshield. Dustfall rates ranged between 172 and 1,998 mg/m^2/day for samplers without windshields and between 191 and 1,934 mg/m^2/day for samplers with windshields. The results indicate that the use of windshields or not, in this instance, is largely a compliance issue.

Keywords: *ASTM D1739, dustfall, fugitive dust, monitoring, South Africa, windshields.*

COMPARISON OF DIFFERENT DUST FALLOUT MEASUREMENT TECHNIQUES WITH SPECIFIC REFERENCE TO THE STANDARD ASTM D1739:1970 TECHNIQUE FOR THE MEASUREMENT OF DUST DEPOSITION IN SOUTH AFRICA

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Abstract

Dust fallout monitoring has become increasingly important in South Africa since the promulgation of the National Environmental Management Air Quality Act (No 39 of 2004) and the National Dust Control Regulations (published in November 2013) issued in terms of this Act. The regulations specify the dust fallout limits for residential and non-residential areas. These are 600 mg/m^2/day on a 30 day average for residential areas and 1200 mg/m^2/day on a 30 day average for non-residential areas. These standards are based on the ASTM D1739:1970 technique for measuring dust fallout. The initial SANS 1929:2005 standard states that ASTM D1739 needs to be used for the measurement of dust fallout without specifying the edition of the ASTM standard. This research reports on the comparison of dust fallout measurement using the ASTM D1739:1970 method with the ASTM D1739:2010 method and the DustWatch multidirectional bucket measurements. Dust fallout measurements have been collected at gold and coal industries to compare the performance between the different apparatuses. The outcome of this study will be to determine if the ASTM D1739:2010 method and the multidirectional bucket provide equivalent results to the ASTM D1739:1970 method. This is of high importance as the ASTM D1739:2010 method and the multidirectional buckets are extensively used in industry and they can only be used for measuring dust fallout rates if they provide equivalent results to the ASTM D1739:1970 method (according to the National Dust Control Regulations).

Keywords: *Dust deposition, dust flux, dust fallout*

SCIENTIFIC PAPERS (continued)

INFLUENCE OF COAL-PARTICLE SIZE ON EMISSIONS USING THE TOP-LIT UPDRAFT IGNITION METHOD

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Abstract
Despite the Government's intervention of an intensive electrification program in South Africa, which has resulted in more than 87% of households being connected to the grid, a majority of low-income households still depend on coal as a primary source of energy, especially on the central Highveld. In informal settlements, combustion of coal is done in inefficient self-fabricated braziers, colloquially known as *imbaulas*. Emissions from domestic coal combustion result in elevated household and ambient air pollution levels that often exceed national air quality limits. Continued dependence on coal combustion exposes households to copious amounts of health-damaging pollutants. Despite the health significance of coal-burning emissions from informal braziers, there is still a dearth of emissions data from these devices. Consequently, evaluating the emission characteristics of these devices and to determine the resultant emission factors is needed. The effects of ignition methods and ventilation rates on particulate and gaseous emission from coal-burning braziers are reported in literature. However, to date there are no studies carried out to investigate the influence of the size of coal pieces on brazier emission performance. In this paper, we report on controlled combustion experiments carried out to investigate systematically, influences of coal particle size on gaseous and condensed matter (smoke) emissions from informal residential coal combustion braziers. Results presented are averages of three identical burn-cycles of duration three hours or fuel burn-out, whichever was the soonest.

Keywords: *Coal particle size; brazier; imbaula, emission factor, smoke*

ESTIMATION OF EXHAUST EMISSION FROM OCEAN-GOING VESSELS FOR THE PORT OF CAPE TOWN

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Abstract

International shipping is recognised as an important sector of the global economy with over 80% of trading goods being transported by ships. Emissions from Ocean-Going Vessels (OGVs) which are generally powered by diesel fuel are thus increasingly contributing to the growing emissions from the transport sector. As 70% of emissions from ships occur within 400 km of coastlines this could lead to air quality related problems within and around coastal towns and harbours. South Africa is home to some of the busiest ports on the African continent, thus highlighting the importance of characterising emissions from OGVs. This paper presents the results of ship emissions inventories that were compiled for the Port of Cape Town for a base year of 2012 using three well known emission inventory methodologies. Results for key greenhouse gas emissions, carbon dioxide (CO_2) and methane (CH_4), and air pollutants such as particulate matter, carbon monoxide (CO), oxides of nitrogen (NO_x), and oxides of sulphur (SO_x) are presented. The approaches, data needs/availability and assumptions of these methods in relation to the case study outcomes are used to make recommendations for a suitable approach that could be used in future research to characterise emissions from OGVs for the other major ports of the country.

Keywords: *Ocean-going vessels, methodologies, greenhouses gases, Port of Cape Town, emission inventory, pollutants*

SCIENTIFIC PAPERS (continued)

THE CONSIDERATION OF NON-ANTHROPOGENIC EMISSIONS FOR AIR QUALITY MODELLING IN SOUTH AFRICA

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Abstract
Air quality modelling requires the identification of all relevant sources of emissions and the accurate calculation of the emissions rates. Many of these sources include anthropogenic activities that need to be accounted for in any emissions inventory to appraise their impact on air quality. Frequently the anthropogenic sources are the easiest to control through various emissions mitigation strategies. However emissions from natural sources can also contribute significantly to air pollution levels and are thus just as important to quantify to avoid underestimation in air quality in simulations. Biomass burning plays a key role in southern Africa's environmental concerns (highlighted by both the Southern African Regional Science Initiative field campaigns, SAFARI'92 and SAFARI2000) as it is associated with land-cover change as well as the release of pollutants into the atmosphere within a relatively short period of time. Biomass burning emissions inclusion in any air quality modelling over southern Africa is necessary. Biogenic emissions can be considered as just as important, especially, if chemical transformation modelling is required. Biogenic Volatile Organic Carbon (BVOC) emissions as well as NO_x from the soil may contribute significantly (depending on vegetation and soil types) within a model domain. Together, biomass burning and biogenic emissions establish a baseline emissions inventory onto which anthropogenic emissions can be added. This paper provides a description of various models and data sources for deriving model ready emissions inventories for biomass burning and biogenic emissions. The results from these models are also presented and discussed.

Keywords: *Natural emissions, biomass burning, biogenic, air quality modeling, Waterberg Air Quality Priority Area*

DEVELOPMENT OF HIGH ACCURACY PROPANE (C3H8) REFERENCE GAS MIXTURES FOR INDUSTRIAL AND STACK EMISSION MEASUREMENTS

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Abstract

Propane reference gas mixtures are used for calibrating a wide variety of analysers for measuring stack and other industrial emissions gases. All emission and automotive industries need to comply with the South African regulations for emissions such as the vehicle emission regulations. In order to achieve this, it is necessary to utilize high accurate and traceable gas standards. Other gas measurement equipment such as gas sensors/detectors used for major hazardous installations requires high accurate reference gas mixtures. These detectors have to be tested to ensure that they are capable of detecting the intended threshold level, and regularly calibrated as their performance invariably drifts with usage. It is therefore important to have measurement capabilities and national measurement standards for propane in South Africa.

This paper describes the development of high accurate propane reference gas mixtures prepared gravimetrically in accordance to International Organization for Standardization (ISO 6142). The essential key factors in developing propane reference gas mixtures considered in this work are the purity assessment of the propane source gases before preparation, weighing system, well developed gas filling system and internal consistency among the mixtures. The internal consistency between the mixtures was verified using gas chromatograph with flame ionisation detector (GC-FID). Our analysis results show that propane reference mixtures produced agree well within the measurement uncertainty of 0.3 %. Finally, the reference gas mixtures were produced with the highest metrological level of 0.5 % expanded uncertainty at 95% confidence level (k=2).

Keywords: *Propane gas mixtures materials, Emission measurements, GC-FID.*

SCIENTIFIC PAPERS (continued)

EMISSIONS MANAGEMENT AND HEALTH IMPACTS: ARE ALL POWER STATIONS EQUAL?

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Abstract

The central objective of the South African National Environmental Management: Air Quality Act, 2004 (NEM:AQA NO. 39 OF 2004) is to enhance the quality of ambient air for the sake of securing an environment that is not harmful to the health and well-being of people. Ambient air quality to which people are exposed therefore lies at the heart of South African air quality legislation. In South Africa air quality is regulated by means of both ambient air quality standards and minimum emission standards (MES) - similar to many developed and developing countries in the world. The listed activities and associated MES identified in terms of section 21 of the NEM:AQA set blanket Minimum Emission Standards for all large boilers (>100 MW) including coal-fired power stations. Tension sometimes arise between the ambient air quality standards and MES, as power stations are expected to comply with MES irrespective of whether ambient air quality standards in their vicinity are met and their potential human health exposure. This may lead to the unnecessary installment of costly abatement technology, the funding which may have been applied with greater effect to health exposure reduction elsewhere. The following question therefore arises, are all coal fired power stations equal in terms of their impact on human health and ambient air quality or does each station have a unique footprint? Fifteen coal-fired power stations in South Africa (of which the results of three power stations are described here) are compared in terms of potential human health exposure to their emissions. Human health exposure is presented by means of intake (the total amount of pollutant from a specific source that enters human lungs) and intake fraction (the mass fraction of a pollutant from a specific source that enters the lungs of humans). It was found that every power station has a unique health impact that is closely associated not only with the emission rate of the power station in question, but also with the proximity to human populations as well as the density and size of these populations. This suggests that it may be more viable to manage emissions from coal-fired power stations on an individual power station basis, rather than utilizing a blanket set of standards, if optimized minimal human health exposure is to be achieved.

Keywords: *exposure, intake, intake fraction, emissions management, coal fired power station.*

SIMULATING FINE RESOLUTION WINDS IN SOUTH AFRICA USING DIFFERENT GLOBAL FORCING FIELDS

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Abstract

On 20 February 2015, a new Laboratory for Atmospheric Studies (LAS) was launched at the University of Pretoria, with support from Eskom and Sasol. One of the objectives of the LAS is generate the best possible atmospheric flow patterns (winds) suitable for application in chemical dispersion modelling in South Africa. To achieve this, the Weather Forecasting and Research (WRF) Regional Climate Model (RCM) model was installed. The principle of nesting historical meteorological fields to finer spatial resolutions requires lateral boundary input which could be obtained from global reanalysis fields. In this study boundary input from two global reanalyses/analysis data sets, namely the European Centre for Medium-Range Weather Forecasts (ECMWF) Interim Reanalysis (ERA-Interim) and the National Centre for Environmental Prediction (NCEP) FiNaL (FNL) data, were separately used as boundary input to the WRF model. Simulations of near-surface temperatures and winds were performed at a 27km x 27km horizontal grid resolution for January and July 2009 over the Marapong (Waterberg priority area) and Elandsfontein (Highveld priority area) weather stations. Hourly WRF model output was verified against hourly observations at these two weather stations. Results indicate relatively small differences between ERA-Interim and FNL forced simulations. A good agreement was found between WRF model simulated and observed near-surface temperatures, while wind comparisons were found to be more variable, especially for January (summer) and at the Marapong weather station.

Keywords: *WRF, nesting, lateral boundary forcing, wind, near-surface temperature.*

SCIENTIFIC PAPERS (continued)

THE INFLUENCE OF GRID RESOLUTION ON WRF-ARW WIND SIMULATIONS FOR ELANDSFONTEIN, MPUMALANGA, SOUTH AFRICA

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Abstract

Hourly observed wind-speed and direction data were taken from ESKOM's Elandsfontein weather station over the period of January 2009. The Weather Forecasting and Research model-Advanced Research WRF (WRF-ARW) was used to generate simulations over the same period, with the first 10 days being used as a spin-up period. The global data utilised for the simulation came from the National Center for Environmental Prediction's FNL (final) Operational Global Analysis data which have an interval of 6 hours and a 1 by 1 degree grid. The WRF-ARW simulations were performed over 4 domain resolutions of 27km, 9km, 3km (situated over the Eastern parts of South Africa) and a 1km domain over the Elandsfontein weather station. The 1km domain that covers the Elandsfontein area has an area dimension of 100km x 100km. The simulation results from 11th to the 31st of January 2009 were selected. Due to time constraints to model over 4 month periods of January, April, July, and October due to their seasonal variations, the January simulation was selected and was interpolated to the position of the Elandsfontein weather station from the 4 domain grid fields. Model results from the 4 domains were verified against the Elandsfontein data, from where model performance according to domain grid resolutions was analysed.

Keywords: *Elandsfontein WRF, model, wind, resolution, simulations, dispersion, pollution*

NIGHTTIME HIGH GROUND-LEVEL OZONE CONCENTRATIONS IN SOUTHERN JOHANNESBURG

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Abstract

A sudden increase in ozone during the night of the 10th and early morning of the 11th of June 2015 is investigated. The increase in ozone was accompanied by increase in wind speed during the same period. The observed increase cannot be explained by the photochemical chemistry for the production of ozone. Hence, the stratospheric ozone intrusion is investigated. It was found that there was a cut-off low pressure system that resulted in the vertical wind transport from the upper troposphere to the lower troposphere which was also evident on the backward trajectories. These disturbances contribute to the high ozone levels observed in the free troposphere, where the atmospheric boundary layer interacts with the upper troposphere resulting in the transportation of stratospheric air close to the surface, thus resulting in the observed tropospheric ozone increase.

Keywords: *Nighttime ozone, stratosphere, cut-off low*

SCIENTIFIC PAPERS (continued)

IDENTIFYING MITIGATION OPPORTUNITIES IN LOW INCOME HOUSEHOLDS

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Abstract

Ambient air quality in low income settlements is a major concern in South Africa. Domestic burning in low income household's account for a large portion of particulate emissions. Possible mitigation opportunities to reduce these high levels of emissions can be done by improving the thermal efficiency of houses which will lower the amount of energy used and burning of coal for heating houses in townships. This will reduce emissions and also lower the carbon footprint. Mitigation measures can include insulating houses better, better coal stoves, better electricity usage etc. This is extremely important to be done in South Africa because people living in low income settlements are extremely vulnerable to diseases etc. Therefore the better the insulation of houses the less electricity will be used which will lower our carbon footprint. Burning of coal in stoves will also be minimized which is a big polluter in low income settlements. Houses with bad thermal efficiency are polluting the atmosphere by burning coal and at the same time using up electricity which South Africa cannot afford. Identifying houses were energy is used in an insufficient manner is done by using infrared imagery. Unmanned Ariel Vehicles (UAV's) was used to map low-income settlements. Houses with poor thermal efficiency are easily identifiable on high resolution infrared images. These are linked with temperature gauges of the ambient air in and outside houses to identify houses were mitigation is needed to better the thermal efficiency. An attempt is made to scale this approach by using satellite imagery. The purpose therefore of this paper is to identify houses with poor thermal efficiency to help find the most appropriate mitigation measures to improve air pollution and energy usage in low income settlements and to evaluate mitigation measures whether it decreases the loss of thermal radiation of houses.

Keywords: *Thermal efficiency, insulation, infrared, low income settlements*

A COMPARISON BETWEEN DUST DEPOSITION CONCENTRATIONS IN DIRECTIONAL AND NON-DIRECTIONAL DUSTFALL SAMPLERS

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Abstract
Dustfall monitoring is regulated by the National Environmental Management: Air Quality Act, Act 39 of 2004, under the National Dust Control Regulations, R. 827 of 2013 (NDCR). The NDCR specifies dustfall standards for Residential and non-residential areas that dust generating industries need to comply with. The method for measuring dustfall is the ASTM D1739: 1970 or equivalent method. The ASTM D1739: 1970, and therefore the NDCR, specifies an open-topped cylindrical collector for dust sampling, without windshield and with water in the sampler. The aim of this study is to correlate values obtained from both directional and non-directional samplers at four sites situated in the Highveld Priority Area. Data has been collected over a period of three years for directional samplers located in close proximity to a non-directional sampler. Using this, it can be determined to what extend can the absolute values obtained from directional samplers be compared against the standards set out by the NDCR. A comparison of the non-directional sampler results with directional sampler results is presented, showing that directional buckets over-represent the dustfall rate and thus should not be compared to the national standard.

Keywords: *Directional Sampler, Dust, Non-Directional Sampler, Standards, Dustfall, ASTM D1739:1970, NDCR.*

SCIENTIFIC PAPERS (continued)

GEOSPATIAL ASSESSMENT OF AIR POLLUTION RISK AS PART OF THE DR. KKDM AQMP

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Abstract
Air quality in South Africa is governed under the National Environmental Management Air Quality, Act 39 of 2004 (NEM:AQA) and related legislation such as the National Ambient Air Quality Standards, 2009 (NAAQS). The NEM:AQA requires Municipalities to introduce Air Quality Management Plans (AQMP) that set out what will be done to achieve or maintain the prescribed air quality standards. Municipalities are required to include an AQMP as part of their Integrated Development Plans (IDP). This study was conducted to develop an AQMP to manage the AQ issues within the Dr. Kenneth Kaunda District Municipality (Dr. KKDM). As part of the AQMP a geospatial assessment of air pollution risk was done.

A spatial assessment of air pollution risk is necessary for effective air quality management. Dispersion modelling is typically used to identify areas where the ambient concentration of particular compounds exceed the national ambient air quality standard. However, emission rates are the biggest uncertainty in dispersion modelling assessments. Although progress has been made towards better inventories of emissions to air in South Africa, there is still a long way to go before having all the necessary information from all the important sources. This leads to assessments that overemphasize sources about which information is available, and under represents sources that are difficult to quantify. This is particularly true for domestic burning. Another problem with dispersion models is the inability to accurately assess intra-urban exposure from large area sources that emit at low temperatures, close to the ground, like residential solid fuel burning (Jerret et al, 2005). This assessment made use of a proximity-based geospatial model that uses nearness to a particular pollution source as a proxy for exposure similar to Wright and Diab, 2009.

The geospatial model represents each source category as a weighted layer. Sources, for which sufficient information was available, were modelled. The sum off all the different layers results in an assessment of how many sources impacts on that particular conurbation. This exposure map is then combined with population demographics in order to assess risk.

Keywords: *Geospatial Assessment, Risk, Air Pollution, Air Quality, AQMP, Dispersion Modelling.*

GASEOUS ELEMENTAL MERCURY (GEM) AT CAPE POINT – A STATISTICAL INVESTIGATION

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Abstract
The Cape Point station is part of the Global Atmospheric Watch (GAW) network initiated by the World Meteorological Organization (WMO). In addition to a comprehensive list of long-term gaseous and aerosol observations, continuous measurements of gaseous elemental mercury (GEM) have been conducted at Cape Point (34.21° S, 18.29° E, South Africa) since March 2007. Atmospheric mercury (Hg) is of global importance since it is subject to long-range transport and partial transformation to highly neurotoxic methylated mercury. Long-term monitoring is important, which can provide valuable information on the oxidation mechanisms of atmospheric Hg. In this study five years of continuous GEM data, together with ancillary data were investigated statistically by using the multi-linear regression (MLR) analysis method. MLR was applied to determine an equation, with ancillary data parameters as independent variables, which could be used to simulate the measured GEM concentrations relatively well. It was also demonstrated that MLR analysis could be used to predict GEM at CPT GAW. Moreover, this equation provided some insight into the complex nature of GEM chemistry. Lastly, the evaluation of both continuously measured and calculated (with the determined MLR Eq. 1) GEM concentrations seem to indicate a decline in GEM concentrations over the period evaluated in this paper.

Keywords: *Gaseous elemental mercury (GEM), statistical analysis, multiple linear regression, Cape Point*

SCIENTIFIC PAPERS (continued)

INDOOR AND AMBIENT PARTICULATE MATTER EXPOSURE ON THE MPUMALANGA HIGHVELD – A CASE STUDY

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Abstract
The household combustion of solid fuels, for the purpose of heating and cooking, is an activity practiced by many people in South Africa. Air pollution caused by the combustion of solid fuels in households has a significant influence on public health. People most affected are those considered to be the poorest, living in low-income settlements, where burning solid fuel is the primary source of energy. Insufficient data has been collected in South Africa to quantify the exposure of people to particulate emissions, especially the respirable fraction, associated with the combustion of solid fuels. The aim of this paper is to evaluate the level of particulate matter exposure for a typical household in a low income settlement in South Africa (KwaDela, Mpumalanga) and to demonstrate that the use of solid fuels in the household can lead to indoor air pollution concentrations reaching well in excess of the National Ambient Air Quality Standards, representing a major national public health threat in the Highveld area of the Mpumalanga Province, South Africa. A mobile monitoring station was used to measure both ambient particulate concentrations and meteorological conditions, while a range of dust/particulate monitors were used for indoor and personal particulate concentration measurements. Indoor and personal measurements are limited to the respirable fraction (PM4) as this fraction contributes significantly to negative health impacts. The sampling for this case study took place from 7- 19 August 2014. The average indoor/outdoor particulate matter ratios varied from 1.6 to 7.1 for $PM_{2.5}$ and from 0.7 to 9.8 for PM_{10}. The personal/indoor particulate matter ratios varied from 0.3 to 1.1 for PM_4 depending on time of the day. Highest particulate matter concentrations were evident during the early mornings and the early evenings, when solid fuel burning activities were at their highest. Indoor hourly PM^4 concentrations reached a maximum of between 270 and 1100 µg/m^3. Indoor daily average PM_4 concentrations were found to exceed the 24h National Ambient PM^{10} Standard of 75 µg/m^3 for 4 days of the 13 day sampling period, whereby the outdoor $PM_{2.5}$ and PM_{10} concentrations were found to be below the standard for the duration of the sampling period. Results indicate that the current focus of national air quality standards on ambient air quality has not taken into account the health risk of domestic burning and its effect on indoor air pollution exposure.

Keywords: *particulate matter exposure, indoor air quality, ambient air quality, personal exposure*

QUALITY ASSURANCE OF CONTINUOUS EMISSION MONITORING SYSTEMS: A PRACTITIONER'S GUIDE/TECHNICAL REPORT

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Abstract

In 2004, the National Environmental Management Act (NEMA) and regulations were promulgated and by 2010 were gazetted into law for the first time in South Africa. Under the NEMA, the Air Quality Act 39 of 2004 (AQA) was promulgated and included priority pollutants identified by the Department of Environmental Affairs (DEA) as having or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage. In this context continuous emission monitoring of emissions to air is a requirement under many of the operators as Air Emission Licenses (AEL) issued under section 21 of AQA. The quality of data obtained from continuous emission monitors is ensured by the inclusion of the BS EN14181:2004 (revised standard updated to current BS EN14181:2014) European standard which has been adopted into the South African legislation for this purpose.With this in mind the purpose of this technical paper is to provide an overview of the current status of automated measuring systems (AMS)/continuous emission monitors(CEMs) currently in use by industry to monitor emissions in South Africa, in terms of compliance with relevant emission limit values (ELVs) and the current challenges faced with ensuring the quality and reliability of the data obtained.

Keywords: CEMS/AMS, EN14181, TGN-M20, QAL1, 2 and 3

SCIENTIFIC PAPERS (continued)

EXPLORING CROSS-SECTIONAL STUDY DESIGN IN THE STUDY OF MAIN ENERGY CARRIER AND RESPIRATORY HEALTH OUTCOMES

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Abstract
Indoor household fuel combustion is said to be responsible for more than 4 million premature deaths per year. More than 50% of premature deaths among children under the age of 5 years are likely caused by inhalation of particulate matter from domestic indoor air pollution. Collecting household data on indoor fuel use and respiratory health outcomes requires careful planning and consideration of limitations. In a cross-sectional survey of 1 360 households, 397 in Mozambique (Massingir) and 963 in South African (Hoedspruit), informed adult household representatives were asked to report on their main energy carrier. No households in Mozambican homes use electricity and 98% relied on wood. Around 15% of South Africa homes used electricity and 85% relied on wood for cooking. Prevalence of diagnosed upper respiratory infections from the preceding 2 weeks of (1) hay fever, (2) ear infection and (3) sinusitis was relatively low in both country samples, but was higher among Mozambicans (prevalence of 14%, 1% and 9%, respectively) compared to South Africans (prevalence of 0.8%, 0.6% and 0.6%, respectively). These results were surprising given the reliance on wood as main energy carrier. Here, we discuss possible reasons for relatively low prevalence of respiratory infections including timing of the study, questionnaire design, under-reporting, use of alternative medical treatment and lack of understanding.

Keywords: *Respiratory health, indoor air quality, cross-sectional study, fuel.*

POSTER INDEX

SOURCE APPORTIONMENT OF SUMMERTIME AMBIENT PM0.4 AND PM8.0 IN KWADELA, A LOW INCOME AREA

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IMPROVING THE EFFICIENCY OF PARTICULATE CONTROL TECHNOLOGIES TO MEET INCREASINGLY STRINGENT EMISSION LIMITS

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AN AIR QUALITY ASSESSMENT OF THE VREDEFORT DOME

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CR(VI) GENERATION DURING FLARING OF CO-RICH OFF-GAS FROM CLOSED FERROCHROMIUM SUBMERGED ARC FURNACES

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CHARACTERISATION OF PRECIPITATION CHEMISTRY AT WELGEGUND

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COUPLING DUST-FLUX SCHEMES WITH A REGULATORY DISPERSION MODEL: A CASE STUDY OF A GOLD MINE TAILINGS STORAGE FACILITY

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ESTIMATING THE HEALTH AND COST BENEFITS OF AN AIR POLLUTION INTERVENTION IN KWADELA, MPUMALANGA

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TESTING THE CAPABILITY OF THE NAME III MODEL IN PREDICTING AIR POLLUTANTS CONCENTRATIONS OVER THE VTPA

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SOURCE APPORTIONMENT OF AMBIENT PARTICULATE MATTER IN KWADELA, MPUMALANGA

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ASSESSMENT OF ANIONIC AND CATIONIC ATMOSPHERIC AEROSOLS COLLECTED AT WELGEGUND

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CHARACTERIZING LIGHT-ABSORBING AEROSOLS FROM RESIDENTIAL SOLID FUEL COMBUSTION IN MPUMALANGA, SOUTH AFRICA

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