PROCEEDINGS OF THE

WABER 2021 CONFERENCE

WEST AFRICA BUILT ENVIRONMENT RESEARCH CONFERENCE

9-11 AUGUST
Labadi Beach Hotel
Accra, Ghana

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KNOWLEDGE, INTERACTION, PEOPLE & LEADERSHIP

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EDITORS: S. LARYEA AND E. ESSAH

WEST AFRICA BUILT ENVIRONMENT RESEARCH (WABER) CONFERENCE
Knowledge, Interaction, People & Leadership

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9th-11th August 2021

Accra, Ghana

EDITORS

Sam Laryea
Wits University, South Africa

Emmanuel Adu Essah
University of Reading, United Kingdom

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Editors

Sam Laryea, Wits University, South Africa
Emmanuel Adu Essah, University of Reading, United Kingdom

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Declaration

All papers in this publication have been through a review process involving initial screening of abstracts, review of full papers by at least two referees, reporting of comments to authors, revision of papers by authors and re-evaluation of re-submitted papers to ensure quality of content.

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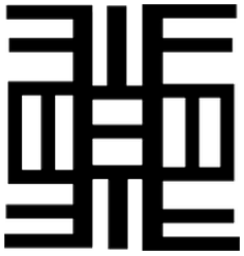

NEA ONNIM NO SUA A, OHU

"*He who does not know can know from learning*"

This is the Adinkra symbol of knowledge, life-long education and continued quest for knowledge. The Akan people in West Africa believe that the search for knowledge is a life-long process. This is evident from the Akan saying "Nea onnim sua a, ohu; nea odwen se onim dodo no, se ogyae sua a, ketewa no koraa a onim no firi ne nsa" which translates into "He who does not know can become knowledgeable from learning; he who thinks he knows and ceases to continue to learn will stagnate".

FOREWORD

I would like to welcome each participant to the WABER 2021 Conference. Since its inception in 2009, the WABER Conference series has done a great deal to nurture and support researchers, initially in West Africa, also, in other parts of Africa and elsewhere. I would like to thank all delegates for your participation which enables us to keep this Conference going.

The WABER Conference enjoys a positive international reputation and has continued to grow from strength to strength over the past 13 years. For this, I would like to thank our team, keynote speakers and participants over the years for every contribution you have made to the success of this Conference. This year's Conference has an excellent programme, line up of speakers and authors.

I would like to thank and commend the authors of all 72 papers in this Conference proceedings. If the research paper writing process was compared to a marathon, the authors of the 72 papers in this publication would be adjudged as the ones who have endured and finished the race.

We opened the call for papers for this Conference in December 2020 and over 100 abstracts were submitted by authors. However, it is one thing to propose to write a paper, and it is quite another thing to actually write the paper. Therefore, I would like to thank and congratulate all authors who succeeded in completing the process of getting published in this conference proceedings.

It is befitting that we have an excellent range of interesting topics in the 72 papers to be discussed at this conference.

We are honoured to welcome Professor Charles Egbu, Vice Chancellor of Leeds Trinity University, to give us a special opening address.

In the three days of this conference, we will have various plenary presentations by experienced international academics and I would like to thank and welcome each of them below.

Professor Albert Chan
Richard Lorch
Professor Taibat Lawanson
Professor Dato' Sri Ar Dr Asiah Abdul Rahim
Professor George Ofori

In addition to these speakers, we have other interesting sessions on the programme including a special session for doctoral students and supervisors several other experienced speakers addressing various topics that should be of interest to many of us.

I would like to thank all members of the organising team particularly Associate Professor Emmanuel Essah, Dr Yakubu Aminu Dodo and Dr Sam Moveh for their efforts which has helped to organise this Conference successfully. I would also like to thank all of our reviewers particularly Associate Professor Emmanuel Essah and Dr Haruna Moda for the considerable time and effort spent reviewing and checking all papers to ensure a high standard of quality.

The WABER Conference Team always plays an excellent role in the success of our events and I would like to thank and appreciate the contributions of Florence, Sam Boakye, Victor Ayitey and his team, Kwesi Kwofie and Issah Abdul Rahman to the success of this Conference.

I hope you enjoy our first hybrid conference and engage with our exciting speakers on the diverse topics that will be covered over the three days of this Conference.

Sam Laryea
University of the Witwatersrand, Johannesburg, South Africa
Chairman of WABER Conference
August 2021

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PEER REVIEW AND SCIENTIFIC PUBLISHING STATEMENT

9th August 2021

TO WHOM IT MAY CONCERN

The scientific information published in peer-reviewed outlets carries special status, and confers unique responsibilities on editors and authors. We must protect the integrity of the scientific process by publishing only manuscripts that have been properly peer-reviewed by scientific reviewers and confirmed by editors to be of sufficient quality.

I confirm that all papers in the WABER 2021 Conference Proceedings have been through a peer review process involving initial screening of abstracts, review of full papers by at least two referees, reporting of comments to authors, revision of papers by authors, and re-evaluation of re-submitted papers to ensure quality of content.

It is the policy of the West Africa Built Environment Research (WABER) Conference that all papers must go through a systematic peer review process involving examination by at least two referees who are knowledgeable on the subject. A paper is only accepted for publication in the conference proceedings based on the recommendation of the reviewers and decision of the editors.

The names and affiliation of members of the Scientific Committee & Review Panel for WABER 2021 Conference are published in the Conference Proceedings and on our website www.waberconference.com

Papers in the WABER Conference Proceedings are published open access on the conference website www.waberconference.com to facilitate public access to the research papers and wider dissemination of the scientific knowledge.

Yours Sincerely,

Sam Laryea, PhD
Chairman of WABER Conference

PEER REVIEW PANEL

WABER Conference is very grateful to each the following persons for your contribution to the peer review process. Thank you so much.

A/Prof Samuel Laryea, Wits University, South Africa
A/Prof Emmanuel A. Essah, University of Reading, UK
A/Prof Carmel Margaret Lindkvist , Norwegian University of Science and Technology, Norway
A/Prof Ian Ewart, University of Reading, UK
A/Prof Joy Maina, Ahmadu Bello University, Nigeria
A/Prof Obinna Ozumba, University of the Witwatersrand, South Africa
Dr Adwoa Serwaa Ofori, Trinity College Dublin, Ireland
Dr Afolabi Dania, University of Westminster, UK
Dr Amna Shibeika, United Arab Emirates University
Dr Amos Darko, The Hong Kong Polytechnic University, Hong Kong
Dr Bruno Lot Tanko, University of Reading Malaysia, Malaysia
Dr Chiahemba J. Nor, Department of Parks and Recreational, Nigeria
Dr. Ing. Collins Ameyaw, Kumasi Technical University, Ghana
Dr Cynthia Adeokun, O. N. A. Architects Ltd, UK
Dr Dave Collins, Norwegian University of Science and Technology, Norway
Dr Erekpitan Ola-Adisa, University of Jos, Nigeria
Dr Faizah Bashir, University of Hail, Saudi Arabia
Dr Folake Ekundayo, Architect at Berkshire Healthcare NHS Foundation Trust, UK
Dr Gabriel Nani, Kwame Nkrumah University of Science and Technology, Ghana
Dr Hafizah Latif, Universiti Teknologi MARA (Perak), Malaysia
Dr Haruna Moda, Manchester Metropolitan University, UK
Dr Humphrey Danso, Akenten Appiah-Menka University of Skills Training & Entrepreneurial Development, Ghana
Dr Immanuel Darkwa, Trinity College Dublin, Ireland
Dr Kwadwo Oti-Sarpong, University of Cambridge, UK
Dr Eng L. Ofetotse, Kingston University, UK
Dr Lawrence Mbugua, University of Reading, UK
Dr Mehdi Shahrestani, University of Reading, UK
Dr Naa Adjeley Ashiboe-Mensah Doamekpor, University of Professional Studies, Accra
Dr Nimlyat S. Pontip, University of Jos, Nigeria
Dr Ogunbode Ezekiel Babatunde, Federal University of Technology Minna, Nigeria
Dr Philippa Boyd, University of Reading, UK
Dr Prince Senyo, University of Southampton, UK
Dr Ron Watermeyer, Infrastructure Options (Pty),Ltd, South Africa
Dr Ronan Champion, University of Reading, UK
Dr Sarfo Mensah, Kumasi Technical University, Ghana
Dr Selorm Adukpo, Oxford Brookes University, UK
Dr Seyi Odeyale, University of Ibadan, Nigeria
Dr Sherif Razak, University of Salford, UK
Dr Sitsabo Dlamini, Wits University, South Africa
Dr Wallace Imoudu Enegbuma, Victoria University of Wellington, New Zealand
Dr. Yakubu Aminu Dodo, Istanbul Gelisim University, Turkey

PRIZES TO BE AWARDED AT THE WABER 2021 CONFERENCE

- **Best Research Paper**

This prize is awarded to recognize the author(s) of an original piece of research which contributes a better understanding of the research question/problem investigated and demonstrates a high degree of scientific quality and innovative thought. This prize was created to acknowledge the continuing importance of high quality research to academic institutions, a researcher's reputation and the development of the built environment field.

- **Best Oral Presentation**

This prize is awarded to recognise the presentation which is the most coherent, clearly enunciated, well-paced, easy to understand, and effective. The award is given on the basis of quality of the presentation and not the written paper. It recognizes the best presentation based on communication of the content of a paper and the ability of the speaker to deliver an impactful, authoritative and engaging presentation. The award looks to encourage researchers to put as much effort as possible into the presentation of their work.

- **Gibrine Adam Promising Young Scholar Award**

This prize is awarded to recognize and encourage exceptional young researchers. The recipient should be a young academic who demonstrates promise, such that he/she is likely to become established as a research leader. The prize is provided by Mr Gibrine Adam – President of Zenith University College and CEO of EPP Books Services – who has made significant contributions to the education sector through his educational establishments and philanthropic work. Awarding this prize each year will serve as an important inspiration for young African built environment academics.

9-11 AUGUST 2021

Labadi Beach Hotel
Accra, Ghana and Online

TIME

08:45am to 16:00pm GMT/UTC

Please note your local time zone may be different

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Meeting ID: 894 6050 4735

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PROGRAMME

WEST AFRICA BUILT ENVIRONMENT RESEARCH CONFERENCE

W W W . W A B E R C O N F E R E N C E . C O M

KNOWLEDGE, INTERACTION, PEOPLE & LEADERSHIP

SPECIAL OPENING ADDRESS ON THE THEME OF

ACADEMIC ASPIRATION AND EXCELLENCE

By Professor Charles Egbu, Vice Chancellor Leeds Trinity University, UK

Keynote presentations by experienced international academics

Professor Charles Egbu
Vice Chancellor
Leeds Trinity University, UK

Professor Albert Chan
Department of Building and Real Estate
Hong Kong Polytechnic University, Hong Kong

Professor Taibat Lawanson
Department of Urban and Regional Planning
University of Lagos, Nigeria

Professor Asiah Abdul Rahim
Department of Architecture,
International Islamic University Malaysia

Professor George Ofori
Dean of School of the Built Environment and Architecture
London South Bank University, UK

Richard Lorch
Editor-in-chief
of Buildings and Cities,
former editor-in-chief of Building Research and Information

DAY 1

MONDAY 9th AUGUST 2021

zoom

WABER 2021 CONFERENCE

08:45-09:00	**WELCOME REMARKS AND INTRODUCTION OF GUEST OF HONOUR BY PROFESSOR SAM LARYEA - CHAIRMAN OF WABER CONFERENCE**		
09:00-10:00	OPENING ADDRESS BY PROFESSOR CHARLES EGBU, VICE CHANCELLOR, LEEDS TRINITY UNIVERSITY, UK Theme: Academic aspiration and excellence		
10:00-10:30	**BREAK**		
10:30-11:15	KEYNOTE ADDRESS BY PROFESSOR ALBERT CHAN, HONG KONG POLYTECHNIC UNIVERSITY, HONG KONG Topic: Current trends and future directions of built environment research		
11:15-11:30	**BREAK**		
11:30-12:40	**PAPER PRESENTATIONS**		
	PARALLEL SESSION 1	**PARALLEL SESSION 2**	**PARALLEL SESSION 3**
11:30-11:35	Session Chair remarks Dr Humphrey Danso, AAMUSTED, Ghana	Session Chair remarks Prof Kulomri Adogbo, Ahmadu Bello University, Nigeria	Session Chair remarks Dr Cynthia Adeokun, O.N.A Architects London
11:35-11:45	Stress-coping strategies among construction personnel: an integrative review - Janet Mayowa Nwaogu and Albert P. C. Chan	Impact of risk factors on construction projects' quality in Nigeria - Ziyadul Hassan Ishaq, Mu'awiya Abubakar, Shehu Muhammad, Yarima Sallau Lawal and Ibrahim Isah	Automated recognition of construction workers' physical fatigue based on foot plantar patterns captured from a wearable insole pressure system - Maxwell Fordjour Antwi-Afari, Heng Li, David John Webb, Shahnawaz Anwer, JoonOh Seo, Kenneth Sungho Park and Alex Torku
11:45-11:55	The relationship between self-efficacy beliefs and career choices of undergraduate built environment students - Mariam Akinlolu and Theo C. Haupt	Awareness and perceptions of construction professionals on environmental risks in construction project delivery in Lagos and Ondo States, Nigeria - Deborah Abosede Ogungbemi and Ayokunle Olubunmi Olanipekun	Socio-psychological motivational needs of unskilled women working in Nigeria's construction industry - Seun Micheal Oloruntoba and Ayokunle Olubunmi Olanipekun
11:55-12:05	**Q&A**		
12:05-12:15	Factors affecting the delivery of building construction projects funded by district assemblies common fund (dacf): the case of selected regions in Ghana - Aborah-Osei Castro and Humphrey Danso	Review of risk management studies: towards a frame of reference for large projects - Rilwan Shuaib Abdulrahman, Ahmed Doko Ibrahim, Baba Adama Kolo and Hassan Adaviriku Ahmadu	Covid-19 pandemic and co-working environment: analysis of shared office space in Federal Capital Territory (FCT), Abuja, Nigeria - Tosin B. Fateye, Abiodun K. Sodiya, Victoria O. Odunfa, Ayodele A. Ibuoye and Adewale R. Adedokun
12:15-12:25	Assessment of residents' perception of infrastructure delivery in Nigeria: the tale of Osogbo - Olatunji Solomon Ayodeji and Olowoporoku Oluwaseun Ayodele	Urban morphology and crime patterns in urban areas: a review of the literature - Idris Isah Iliyasu, Aldrin Abdullah and Massoomeh Hedayati Marzbali	The potential role of green infrastructure on mental health and well-being: the covid-19 pandemic experience - Adedo-tun Ayodele Dipeolu and Akintunde Olaniyi Onamade
12:25-12:35	**Q&A**		
12:35-12:40	Session Chair remarks Dr Humphrey Danso, AAMUSTED, Ghana	Session Chair remarks Prof Kulomri Adogbo, Ahmadu Bello University, Nigeria	Session Chair remarks Dr Cynthia Adeokun, O.N.A Architects London
12:40-13:30	**BREAK**		

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WABER 2021 CONFERENCE

MONDAY 9th AUGUST 2021

DAY 1

13:30-14:40	PAPER PRESENTATIONS		
	PARALLEL SESSION 1	PARALLEL SESSION 2	PARALLEL SESSION 3
13:30-13:35	Session Chair remarks Dr Humphrey Danso, AAMUSTED, Ghana	Session Chair remarks Prof Kulomri Adogbo, Amadu Bello University, Nigeria	Session Chair remarks Dr Cynthia Adeokun, O.N.A Architects London
13:35-13:45	Assessing the causes of material wastage as it affects various building materials on Nigerian construction sites - A. A. Salihu, S. Gambo, M. M. Sa'ad, F. M. Oyeleke and J. Usman	Performance–based EPC contracting: a preliminary study of the challenges of engineering procurement and construction projects in Nigeria Aluko-Olokun Bukola Adenike, Baba Adama Kolo,Mustapha Abdulrazaq and Peter C. Gangas	BIM utilization in facilities management practice: a status study in South Africa - Faith Dowelani and Aghaegbuna O. U. Ozumba
13:45-13:55	Determination of factors that influence labour output on construction sites in Ghana - Joseph Henry Acquah, Humphrey Danso and Emmanuel Bamfo-Agyei	Enablers of mutual satisfaction in transnational public infrastructure development: the case of Sino- Ghana - Bridget Tawiah Badu Eshun, Albert P.C. Chan and Frank D.K. Fugar	The benefits of building information modeling in architectural education in Nigeria - Elimisiemon Monday Chris, Poopola J. O. and Salisu A. S.
13:55-14:05	Q&A		
14:05-14:15	Examination of energy consumption reduction measures for residential buildings in tropical climate (A Case Study of Birnin Kebbi, Nigeria) - Nkeleme Emmanuel Ifeanyichukwu, Sani Abdulrahman Tolani, Winston Shakantu and Mbamali Ikemefuna	Towards a research agenda for smart contract adoption in less technologically enabled construction environments: a systematic literature review - Ekweani Chioma Precious, Kolo Baba Adama, Adogbo Kulomri Jaule and Mohammed Abdullahi	BIM education ontology: towards a research agenda for non-industrialized economies - Abdulazeez Abdulmumin, B. A. Kolo, Y. G. Musa-Haddary and P. G.Chindo
14:15-14:25	An investigation into the use of building information modelling and its impact on construction performance within Ghanaian constructionindustry - Frederick Kwasi Wirekoh and Humphrey Danso	Key factors for electronic procurement systems in the promotion of sustainable procurement in construction projects - Sitsofe Kwame Yevu, Ann Tit Wan Yu, Amos Darko and Mershack Opoku Tetteh	Advancements in computer-aided design and the challenges for architectural education in Nigeria – feedback from the students' industrial work experience scheme - Sunday A. Bobadoye, Dorcas A. Ayeni, Saidat D. Olanrewaju andAjenifujah-Aminat O. Ajenifujah-Abubakar
14:25-14:35	Q&A		
14:35-14:40	Session Chair remarks Dr Humphrey Danso, AAMUSTED, Ghana	Session Chair remarks Prof Kulomri Adogbo, Amadu Bello University, Nigeria	Session Chair remarks Dr Cynthia Adeokun, O.N.A Architects London
14:40-15:00	BREAK		
15:00-15:45	KEYNOTE ADDRESS BY PROFESSOR GEORGE OFORI, LONDON SOUTH BANK UNIVERSITY, UK Topic: Construction in developing countries: need for new concepts and theorising of contextual specificities to the global corpus of knowledge		
15:45-16:00	WRAP UP AND CLOSE - SAM LARYEA, WITS UNIVERSITY, SOUTH AFRICA		

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DAY 2

TUESDAY 10th AUGUST 2021

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WABER 2021 CONFERENCE

08:45-09:00	**CHECK-IN AND OVERVIEW OF WHAT WE WILL COVER FOR THE DAY** **EMMANUEL ESSAH, UNIVERSITY OF READING, UK**		
09:00-10:00	SESSION FOR DOCTORAL STUDENTS AND SUPERVISORS - BY PROFESSOR ALBERT CHAN AND PROFESSOR GEORGE OFORI Topic: Experiential tips for doing and supervising doctoral research successfully		
10:00-10:15	**BREAK**		
10:15-11:15	EDITOR'S FORUM PRESENTATION BY RICHARD LORCH (EDITOR-IN-CHIEF OF BUILDINGS AND CITIES and FORMER EDITOR-IN-CHIEF OF BUILDING RESEARCH AND INFORMATION) FOLLOWED BY 15 MINS Q&A Topic: Elements of a good research article and what the editors and reviewers of top journals look for in modern scientific research articles		
11:15-11:30	**BREAK**		
11:30-12:40	**PAPER PRESENTATIONS**		
	PARALLEL SESSION 1	**PARALLEL SESSION 2**	**PARALLEL SESSION 3**
11:30-11:35	Session Chair remarks Dr Haruna Moda, Manchester Metropolitan University, UK	Session Chair remarks Prof Kola Akinsomi, Wits University, South Africa	Session Chair remarks Dr Amina Batagarawa, Baze University, Nigeria
11:35-11:45	Application of Information and Communication Technology on the implementation of health and safety measures by construction firms in Abuja, Nigeria - Abdullateef Adewale Shittu, Anita Dzikwi Adamu, Abel John Tsado, Lois Adedamola Arowolo and Shakirat Remilekun Abdulazeez	Challenges to sustainable affordable housing using frugal innovation David Mbabil Dok-Yen, Duah Daniel Yaw Addai and Michael Nii Addy	Analytical nexus of urban liveability, liveable communities and place-making in African cities - Samuel Medayese, Hangwelani Magidimisha-Chipungu, Ayobami Popoola and Lovemore Chipungu
11:45-11:55	Assessment of the challenges and solutions to implementation of safety measures by small and medium sized construction firms in Abuja, Nigeria - Jibril Adamu Muhammad, Abdullateef Adewale Shittu, Yakubu Danasabe Mohammed, John Ebhohimen Idiake and Zannah Alhaji Ali	Development of social housing agenda to solve housing deficit in sub-Sahara Africa: a case for Ogun State, Nigeria - Babatunde Adekoyejo Jolaoso and Olusegun Olaopin Olanrele	Users' assessment of the relationship between housing quality and the conditions of residential outdoor spaces in Ilesa, Nigeria - Yussuf Shakirat Oladayo, Jiboye Adesoji David, Agbabiaka Hafeez Idowu, Adeyemi Toyin Ebenezer and Oke Oluyemi Ebenezer
11:55-12:05	**Q&A**		
12:05-12:15	An Investigation into the safety performance of public buildings in relation to compliance of fire safety regulations: a case study of Ashanti and Greater Accra Regions of Ghana - Samuel Asumadu Roberts and Humphrey Danso	Housing affordability in Osogbo Osun State Nigeria - Akinremi Adenike R., Adedayo Adeyanju G., Saheed Jelili, Yussuf Shakirat O. and Ojo Omotayo 'Mubo	Awareness and acceptance of smart security system among occupants of selected public buildings in central business district (FCT-Abuja) Nigeria - Fatima Baba Ciroma, Musa Lawal Sagada and Joy Joshua Maina
12:15-12:25	Evaluation of health and safety compliance of construction projects in south east Nigeria - Chidinma Amarachukwu Emma-Ochu, Kevin C. Okolie and Ikem Mbamali	Factors influencing perceived value of residential properties in Free State Province, South Africa - Kahilu Kaji-mo-Shakantu, Barend Groenewald and Timothy O. Ayodele	Awareness of green infrastructure and its socio-demographic predictors among residents of Lagos metropolis, Nigeria - Adedotun Ayodele Dipeolu, Eziyi Offia Ibem, Joseph Akinlabi Fadamiro, Gabriel Fadairo, Joseph Adeniran Adedeji and Akintunde Olaniyi Onamade
12:25-12:35	**Q&A**		
12:35-12:40	Session Chair remarks Dr Haruna Moda, Manchester Metropolitan University, UK	Session Chair remarks Prof Kola Akinsomi, Wits University, South Africa	Session Chair remarks Dr Amina Batagarawa, Baze University, Nigeria
12:40-13:30	**BREAK**		

WABER 2021 CONFERENCE

TUESDAY 10th AUGUST 2021

DAY 2

13:30-14:40	PAPER PRESENTATIONS		
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13:30-13:35	Session Chair remarks Dr Samuel Moveh, Universiti Teknologi Malaysia, Malaysia	Session Chair remarks Prof Kola Akinsomi, Wits University, South Africa	Session Chair remarks Dr Yakubu Aminu Dodo, Istanbul Gelisim University, Turkey
13:35-13:45	A study on interpersonal skills of Nigerian built environment professionals for the successful delivery of mass housing programmes - Mansir Dodo, Muhammad M. Gambo, Kabir Bala and Badamasi Abdulmalik	Micro-climatic benefits of Green infrastructure (trees) in a Housing Estate in Abuja, Nigeria - Tobi Eniolu Morakinyo, Olumuyiwa Bayode Adegun, Morisade O Adegbie and Olawale Oreoluwa Olusoga	Spatial accessibility to urban infrastructure services among hotels in the small city of Wa, Ghana Elvis Attakora-Amaniampong, Appau Williams Miller and Emmanuel K. Derbile
13:45-13:55	Adoption of technology in human resource management - a new normal - Kuforiji, A. Aramide	Investigating the effect of covid-19 driven inflation on commercial property hedging capacity in Lagos, Nigeria - Muktar Babatunde Wahab, Wasiu Ayobami Durosinmi, Matthew Mamman, Yetunde Christianah Charles-Afolabi and Dodo Usman Zakari	Modeling of future land use/land cover change dynamics in Lagos, Nigeria using cellular automata and Markov chain (Ca-Markov) - Auwalu Faisal Koko, Wu Yue, Muhammed Bello and Ghali Abdullahi Abubakar
13:55-14:05	**Q&A**		
14:05-14:15	Assessing the level of awareness on the concept of Design for Safety (DfS) amongst design professionals in the construction industry in Nigeria - Mu'awiya Abubakar, Bello Mahmud Zailani and Abdulgafar Adamu	Students' perceptions about training on property valuation techniques in selected tertiary institutions in Nigeria - Augustina Chiwuzie, Daniel Ibrahim Dabara, Edith Mbagwu Prince, Sayo Tolani Olawuyi and Sayo Tolani Olawuyi	Assessment of factors responsible for outsourcing of facilities management services in public hospitals within Kaduna metropolis - Aliyu Suleiman Shika, Mohammed Mustapha Saad and Abdullahi Getso Ibrahim
14:15-14:25	An exploration of spatial layout and communication patterns in tertiary hospital design: an innovative approach to sustainable hospital design - Ejeh David Ekoja, Sagada Musa Lawal, Oluigbo Stephen Nwabunwanne, Maina Joy Joshua and Sufiyan Mu'awiyyah Babale	Predictors of academic attainment in a Nigerian polytechnic: perceptions of estate management students - Augustina Chiwuzie	An innovative approach for the evaluation of expansion option in buildings - Yarima Sallau Lawal, Aliyu Makarfi Ibrahim, Mu'awiya Abubakar and Ziyadul Hassan Ishaq
14:25-14:35	**Q&A**		
14:35-14:40	Session Chair remarks Dr Samuel Moveh, Universiti Teknologi Malaysia, Malaysia	Session Chair remarks Prof Kola Akinsomi, Wits University, South Africa	Session Chair remarks Dr Yakubu Aminu Dodo, Istanbul Gelisim University, Turkey
14:40-15:00	**BREAK**		
15:00-15:45	KEYNOTE ADDRESS BY PROFESSOR TAIBAT LAWANSON, UNIVERSITY OF LAGOS, NIGERIA Topic: Rethinking current approaches to urban development in Africa		
15:45-16:00	**WRAP UP AND CLOSE - EMMANUEL ESSAH, UNIVERSITY OF READING, UK**		

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DAY 3

WEDNESDAY
11th AUGUST
2021

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WABER 2021 CONFERENCE

08:45-09:00	**CHECK-IN AND OVERVIEW OF WHAT WE WILL COVER FOR THE DAY PROFESSOR SAM LARYEA, WITS UNIVERSITY, SOUTH AFRICA**		
09:00-10:00	KEYNOTE ADDRESS BY PROF ASIAH ABDUL RAHIM, INTERNATIONAL ISLAMIC UNIVERSITY, MALAYSIA Topic: Current trends and future directions in the inclusive, sustainable and tropical design of built facilities		
10:00-10:30	**BREAK**		
10:30-11:15	KEYNOTE ADDRESS BY PROF ALBERT CHAN, HONG KONG POLYTECHNIC UNIVERSITY, HONG KONG Topic: Insights for developing individual and institutional research areas and strategies in construction and real estate		
11:15-11:30	**BREAK**		
11:30-12:40	**PAPER PRESENTATIONS**		
	PARALLEL SESSION 1	**PARALLEL SESSION 2**	**PARALLEL SESSION 3**
11:30-11:35	Session Chair remarks Dr Maxwell Fordjour Antwi-Afari, Aston University, UK	Session Chair remarks Dr Humphrey Danso, AAMUSTED, Ghana	Session Chair remarks Dr Sarfo Mensah, Kumasi Technical University, Ghana
11:35-11:45	Conceptual framework for whole-life cost data transformation and model selection - Ibrahim, A., M. , Bala, K. , Ibrahim, A. D. , Zubairu, I. K.	Water absorption quality of clay bricks made by emerging manufacturers in SouthAfrica Bonga PraiseGod Khuzwayo	Comparative analysis of soundness and setting time of Portland cement of three companies in Nigeria - Angulu Haruna, Abba Musa, Samaila Hamza, Galadima Muhammad and Odesanmi, Atinuke
11:45-11:55	The impact of project contributory factors on the cost performance of building projects - V. H. Jiya, A. D. Ibrahim, D. Kado and K. Bala	Effects of sand on the properties of cement-laterite interlocking blocks - Sampson Assiamah and Humphrey Danso	Effect of cereal flours on the properties of concrete - Alfa Nasirudeen Musa and Adeleke Babatunde Kazeem
11:55-12:05	**Q&A**		
12:05-12:15	Developing a framework for public private partnership project governance in Nigeria - Atoyebi Kayode Emmanuel and Ojo Stephen Okunlola	Effect of petroleum contamination on some selected properties of compressed stabilized earth brick (CSEB) K. A. N. Sackey, M. M. Garba, O. G. Okoli and D. D. Dahiru	Effect of palm kernel shell as coarse aggregate on the properties of concrete A.G. Ibrahim, A. Yahya, M.M. Gambo, S. Gambo and J. Usman
12:15-12:25	Contractors' selection and its effects on water infrastructure delivery Mkasi P., Ogbeifun E. and Pretorius J. H. C.	Suction of clayey soil treated with quarry dust base geopolymer cement for sustainable pavement subgrade construction - Ezenwa Chinenye Amanamba and Kennedy Chibuzor Onyelowe	Effects of maximum aggregate sizes on flexural strength of recycle iron and steel slag (RIIS) concrete - Oluwaleke Adekunle Olowu, Akeem Ayinde Raheem, Abiodun Yesiru Akinsanya and Victor Ikechukwu Opara
12:25-12:35	**Q&A**		
12:35-12:40	Session Chair remarks Dr Maxwell Fordjour Antwi-Afari, Aston University, UK	Session Chair remarks Dr Humphrey Danso, AAMUSTED, Ghana	Session Chair remarks Dr Sarfo Mensah, Kumasi Technical University, Ghana
12:40-13:30	**BREAK**		

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Professor Charles Egbu
Vice Chancellor
Leeds Trinity University, UK

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Professor Charles Egbu joined Leeds Trinity University as Vice-Chancellor on 1 November 2020. He leads the University on all strategic matters; ensuring financial sustainability to allow the delivery of the University's Strategic Plan, including the overall vision and values of the University. He represents the University externally at various groups including Universities UK (UUK), Million Plus and the Cathedral's Group. He works closely with industry and professional bodies, especially in the Built Environment sector, and with local communities.

Professor Egbu's research interests focus on project management, construction management and sustainable development; subjects about which he has written 12 books and contributed to more than 350 publications in various international journals and conferences. He has supervised over 25 PhD students and examined over 100 PhD candidates world-wide. In addition, he has acted as an external examiner to many undergraduate and postgraduate programmes in universities all over the world

Richard Lorch
Editor-in-chief
of Buildings and Cities,
former editor-in-chief of Building
Research and Information
and executive editor
of Climate Policy

WABER 2021 CONFERENCE
INVITED SPEAKER FOR THE EDITOR'S FORUM ON TUESDAY 10TH AUGUST

Richard Lorch is an architect, researcher, writer and editor-in-chief of Buildings & Cities. He was the former editor-in-chief of Building Research and Information and executive editor of Climate Policy.

He is a visiting professor at University College London and Politecnico di Milano and on the advisory board of the Dresden Leibniz Graduate School. He works on organisational / policy responses to climate change - mitigation and adaptation paths - and the environmental impacts of the built environment and building performance at different scales from the individual building to neighbourhood to city.

As editor, his key concerns are fair, robust peer review assessment and feedback processes, author support and the diffusion and take-up of research and new knowledge by 'end users' - promoting two-way dialogue and co-production between stakeholders, practitioners, policy makers and the academic community.

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KEYNOTE SPEAKER

Professor Albert Chan
Department of Building
and Real Estate
Hong Kong Polytechnic University,
Hong Kong

Professor Albert Chan is Associate Director of RISUD and Able Professor in Construction Health and Safety and Chair Professor of Construction Engineering and Management, Hong Kong Polytechnic University, Hong Kong.

A Chartered Construction Manager, Engineer, Project Manager, and Surveyor by profession, Prof. Chan has worked in a number of tertiary institutions both in Hong Kong and overseas. He was a Senior Lecturer and Deputy Head of the School of Building and Planning at the University of South Australia.

Professor Chan joined the Department of Building and Real Estate of the Hong Kong Polytechnic University in 1996 and was Associate Head (Teaching) from 2005 to 2011; Associate Dean and Interim Dean of the Faculty of Construction and Environment from 2011 to 2013, and from 2013 to 2014 respectively.

His outstanding research performance has resulted in the appointment of Able Professor in Construction Health and Safety in August 2019. He has produced over 1,000 research outputs in refereed journal papers, international refereed conference papers, consultancy reports, and other articles. He has won numerous prestigious research paper and innovation awards since 1995. Professor Chan served as an expert member in the Built Environment Panel of FORMAS, Swedish Research Grants Council. He was also an expert member to assess the research performance of the Faculty of Architectural and the Built Environment, TU Delft, the Netherlands. Professor Chan is currently an expert member of the Engineering Panel of the Research Grants Council, HKSAR.

Professor Chan holds an MSc in Construction Management and Economics from the University of Aston in Birmingham, and a PhD in Project Management from the University of South Australia. He has been an Adjunct Professor in a number of universities. Professor Chan was also a Founding Director of Construction Industry Institute, Hong Kong, which was a joint research institution developed by industry and the academia.

Professor Taibat Lawanson
Department of Urban and
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University of Lagos, Nigeria

WABER 2021 CONFERENCE
KEYNOTE SPEAKER

Professor Taibat Lawanson is a Professor in the Department of Urban and Regional Planning at the University of Lagos, Nigeria, where she leads the Pro-poor Development and Urban Management Research Cluster. She is also co-director at the University of Lagos Centre for Housing and Sustainable Development. She holds a PhD in Urban and Regional Planning from the Federal University of Technology, Akure, Nigeria.

She has conducted extensive research on issues relating to urban informality, livability,environmental justice and pro-poor development. She is interested in how formal and informal systems can synthesize in the emerging African city, and written or co-authored over 60 articles in peer-reviewed journals, books and conference proceedings and enjoyed funding support for her work from UKAid, USAID, Cambridge Alborada Research Fund, GCRF, British Academy and University of Beyreuth 'Africa Multiple' among others. She is a member of the editorial advisory board of Area Development and Policy Journal of the Regional Studies Association and International Corresponding Editor at Urban Studies Journal.

She is also a member of the advisory committee of UNHABITAT fl agship 'State of the World's Cities Report'. She is a registered town planner and a member of the Hunan Capacity Development Association,Urban Aff airs Association and International Society of City and Regional Planners among others.Taibat is a proud alumnus of the prestigious Rockefeller Foundation Bellagio Academic Residency and is a 2013 World Social Science Fellow of the International Social Science Council.

Professor Asiah Abdul Rahim
Department of Architecture,
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WABER 2021 CONFERENCE
KEYNOTE SPEAKER

Professor Dato' Sri Ar Dr Asiah Abdul Rahim, is a Professor at the Department of Architecture in Kulliyyah of Architecture and Environmental Design (KAED), International Islamic University Malaysia (IIUM), apart from being a Professional Architect, she used to managed her own Architectural Firm, DASAR Architect, she is also a renowned architect in Designing and managing construction for various building typologies. She is also Universal Design Expert and an Access Audit Consultant.

She obtained her PhD from Oxford Brookes University in Oxford, United Kingdom with her previous degree of B. Arch from Deakin University in Australia and a Diploma in Architecture from our local University of Technology Malaysia (UTM). She was among the pioneer lecturers in establishing Kulliyyah of Architecture & Environmental Design (KAED) of International Islamic University Malaysia (IIUM) about 22 years ago.

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KEYNOTE SPEAKER

Professor George Ofori
Dean of School of the Built Environment and Architecture
London South Bank University, UK

Professor George Ofori specialises in Construction Management and Economics, at the project, company and industry levels. His main subject of research is the improvement of the capacity and capability of the construction industry, especially in developing countries. Professor Ofori was educated at the University of Science and Technology in Kumasi, Ghana where he obtained a BSc (Building Technology in Quantity Surveying) (First Class Honours). He worked briefl y in that university as a Teaching Assistant before proceeding to the UK to study for an MSc (Building Economics and Management) (Distinction) degree at University College London, from where he also obtained a Ph.D. degree in 1981.

He was subsequently awarded a DSc degree by the University of London in 1998. Professor Ofori is a Fellow of the Ghana Academy of Arts and Sciences. Professor Ofori worked with G.A. Takyi and Partners in Accra, Ghana, as a Senior Quantity Surveyor for two years.

From 1983 to 2017, he was employed by the National University of Singapore, where he was promoted to Full Professor in 1999, and was the Head of the Department of Building for fi ve years. He has been a consultant to many governments and international agencies on construction industry development.

We would like to sincerely thank
all our distinguished speakers
for accepting to be part of this year's

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HOUSEHOLDS' EXPOSURE TO INDOOR AIR POLLUTION FROM FOSSIL FUEL ELECTRIC GENERATOR USE IN MINNA NIGERIA

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Lack of reliable access to modern energy in Minna Niger state results in households 'use of inefficient alternatives especially fossil fuel generators for domestic purposes. The study analyses indoor air pollution from households 'use of generator with a view to determining their exposure to Carbon monoxide. The concepts of energy access, poverty and generator pollution were reviewed. The research employed empirical approaches and adopted the multi-stage sampling technique. The study area has a population of 63,873 households. MSA Altair 5X Multigas detector was employed in the detection of pollution (CO) levels emanating from the generator use. It revealed that inefficient use of generator, generates 60 ppm, above the WHO and NAAQS threshold of 10 ppm. 66.4% of the generator using households are exposed to dangerous levels of CO pollution from generator use at ≤4 meters 'distance in Minna, Nigeria. The study concluded that households 'access to adequate electricity de-emphasizes the need for generator ownership and use. Households 'liveability is undermined by high level of pollution. It recommended enlightenment on the dangers of exposure to carbon monoxide and that generators should be operated at a minimum distance of 4 meters away from residential buildings.

Keywords: carbon monoxide, domestic energy, energy poverty, generator

INTRODUCTION

Epileptic power supply is being experienced by households in Minna, the capital of Niger state the acclaimed 'power state 'of Nigeria. They barely experience 24 hours of uninterrupted power supply despite being the host state of three hydro power stations. This lack of steady electricity energy plunges the households into domestic energy poverty situation as most domestic activities requiring energy

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revolves around electricity energy. Power outage makes them vulnerable security wise especially at night. Increased households 'energy expenditure and pollution exposure is experienced when inefficient alternatives are used especially fossil fuel generators. The generators are majorly resorted to because apart from illumination that other inefficient alternatives can offer, they offer other services such as powering appliances. Fumes from generators contributes to climate change and most importantly increases morbidity and mortality rate through indoor air pollution. Households are at risk when generators are used inefficiently such as in the garage, veranda, balcony, unused rooms, etc. Therefore, the study analyses indoor air pollution associated with generator use in Minna Nigeria with a view to determining households 'exposure to carbon monoxide indoor pollution that will champion the need to play safe in the operations and use of fossil fuel generators.

LITERATURE REVIEW

Energy access

In spite of modern energy services being germane to both human and economic development, still electricity is not accessed by over 1.3 billion people (World Energy Outlook (2002). Electricity is needed for lighting, heating, boiling, and cooking and mainly for various domestic appliances operation. However, the inadequacy in generating electric power likewise poor distribution network has subjected a large chunk of the citizenry to inefficient alternatives of Portable Power Electricity Generator (PPEG), kerosene lantern and candle use for their domestic lighting needs. This, puts them at health risk and invariably increases their household expenditure (Ohadugha 2018). Globally, fossil fuel dependent economy and the greenhouse gas emissions increase is drastically changing the climate system and having a noticeable global impact (UNDP 2016).

Resulting from the epileptic nature of electricity supply, a great percentage of urban dwellers and also industries rely on electricity generating plants (Ladan 2013). The result is that operating of the generators has become a source of both indoor and outdoor air pollution in the urban centres. Quantities of smoke and particulates are generated when generators are inefficiently operated as result of the age, lack of maintenance and operational factors (Ohadugha 2018). On daily basis, average level of indoor emitted pollutants often goes beyond current World Health Organisations guidelines and acceptable levels of 9-10 parts per million (ppm).

Table 1: Nigerian ambient air quality standard

Air Pollutants	Emission Limits
Particulates	250 (µg/m3)
SO_2	0.1 (ppm)
Non-methane Hydro carbon	160 (µg/m3)
CO	11-4 (µg/m3) or 10 (ppm)
NOX	0.04-0.06 (ppm)
Photo chemical Oxidant	0.06 (ppm)

Source: Federal Ministry of Environment (FME, 1991)

In Nigeria, the ambient air quality maximum limit as approved by the Federal Ministry of Environment, Housing and Urban Development (FME & UD) is 10 ppm - 20 ppm for an average time of 8 hours (Abdulkarim et al. 1990). The WHO

standards in Table 1 were adopted as the national standards for residential buildings gaseous emissions against which air quality parameters monitored are compared in order to determine its "cleanliness" (Federal Ministry of Environment 1991).

Electric generator and air quality

Electricity supply is one public service that has witnessed uncomplimentary remarks from both members of the public and policy analysts over the years and this has generated a series of adaptations including proliferation of private small electricity generating plants (Sanusi 2008). This leads to environmental pollution and increased greenhouse gases due to emissions.

The emissions emanating from Portable Power Electricity Generator (PPEG) has become a major indoor air pollution problem in the country and areas experiencing bad electric power situation (Adefeso et al. 2012). Using PPEG to make up for power shortages, owners most often operate them indoors or very close to their homes in response to generator theft and serene disturbance to neighbours (Ashmore and Dimitroulopoulou 2009). Furthermore, indoor levels of air pollutants can be increased by inadequate ventilation. Supporting the observation above, inadequate windows aggravate indoor pollutants accumulation (White and Marchant 2009). United States Consumer Product Safety Commission (US CPSC) reported that generator positioned near open windows, doors, or vents outdoors accounted for 4.8% deaths caused by generator carbon monoxide poisoning (Marcy and Ascon 2004). The carbon monoxide emission factor from PPEG's powered with gasoline was determined and was proved that carbon monoxide concentrations within enclosures dissipates quickly with high rate of air exchange and further concluded that PPEG should be placed above 10 meters away, if wind direction is towards the building (Adefeso et al. 2012).

Generator use impacts both negatively and positively (Ohadugha 2018). Negatively, the use of PPEG impacts on the health of both the users and those around it through the air pollution and noise. In Nigeria, households operate generators for six hours on the average daily (Stanley et al. 2010) with average distance of 5.6m from building contrary to 10m minimum proposed by Adefeso et al. (2012). Along with poor ventilation, these factors have negatively influenced households 'indoor air quality implying that the households are exposed to some concentrations of carbon monoxide (Ladan 2013). The most commonly identified reasons of CO poisoning from PPEG in the observations of Hampson and Zmaef (2005) are ignorance of CO poisoning and ventilation requirements likewise operating generators indoor, especially in the garage. Accordingly, increase in indoor carbon monoxide level in India is attributable to PPEG use in their urban areas (Lawrence et al. 2004). In 2008 alone in Nigeria, more than 60 people suffocated to death resulting from the CO effects due to their exposure to its high concentrations (Adefeso et al. 2012). An individual's health condition, length of exposure as well as the CO concentration determines the health effects (Ohadugha 2018). The effects on people differ though dependent on the CO level and the individual peculiarities (WHO 2000).

MATERIALS AND METHOD

Study area

Minna doubles as the capital of Niger state and the headquarters of Chanchaga Local Government Area (Niger state statistical year book year 2011). Chanchaga Local Government Area is encapsulated by Bosso Local Government Area of Niger state. It lies between Latitude 9o 33 'and 9o 40 'North of the Equator and Longitudes 6o 29 'and 6o 35 'East of the Greenwich Meridian on a geological base of an undifferentiated basement complex of mainly gneiss and magnetite (Max Lock Nigeria Limited 1979). The state has an area of about 76,363km2. With Shiroro, Kainji and Jebba Hydro-Electric Dams of Nigeria located in Niger State, the state is the acclaimed "Power Generating House" of the Nigeria with the slogan "Power State".

Methodology

This study analyses households 'exposure to indoor air pollution which entails detecting and measuring the level of pollutants concentration indoors, specifically carbon monoxide resulting from domestic use of electric generators. The research is a household and empirical survey as both primary and secondary data were sourced using semi structured questionnaire from the eventual randomly selected households. Also, portable hand-held gas detector/monitor (MSA Altair 5x Multigas Detector) was used to detect and capture carbon monoxide concentration in the generator using households while the generator is running irrespective of the reason for using generator.

The analysis was done with Statistical Package for the Social Sciences (SPSS) as a tool. In order to examine households 'exposure to indoor pollution induced by generator use in Minna, the generators mode of use was examined. Gas concentrations indoors were discerned using MSA Altair 5X Multigas Detector which aided determining the level which urban residents are exposed to indoor pollution in the study area. The MSA Altair 5X Multigas Detector Version: SW 1.27.06.50 S/N: 0056759 manufactured by Mine Safety Appliances Company; 1000 Cranberry Woods Drive Cranberry Township, PA 16066 USA is a portable hand-held device used to measure the concentration of gases in the environment. The device is available with a maximum of four sensors, which can display readings for five separate gases (one Dual Toxic Sensor provides both CO and H2S sensing capabilities in a single sensor), Oxygen (O2) and 2 combustible gases including Pentane.

Population and sampling technique

The 2018 projected population of the study area which is 319,366 and with national household size average of five (https://dhsprogram.com/pubs/pdf/FR148/02 Chapter02 .pdf) resulted to approximately 63,873 households.

Using online sample size calculator with confidence level of 95% and 5% margin of error, the sample size is 382. Extra 18 questionnaires were added to make up for possible unanswered rounding it up to 400. Eventually, they were all correctly filled and returned. Hence, 400 copies of the research instrument were proportionally distributed to households in the neighbourhoods making up the study area according to their population. Multi-stage sampling technique involving clustering

(neighbourhoods), stratifying (residential houses) and purposive randomising (households using generators) was adopted for the study in selecting the sampled units.

RESULTS AND DISCUSSION

This section evaluates households 'exposure to indoor pollution in Minna metropolis. It involves analysing the generator use, operating position and distance and their emission (carbon monoxide concentration) to determine the safety or otherwise of the households.

Alternative lighting energy

With the incessant power outage experienced in the study area, the primary domestic energy types used for lighting during power outage include solar, inverter, generator, kerosene lantern, rechargeable lanterns, torchlight and candle. For the purpose of the study which involves pollution, generator was considered. Other prevalent pollutant emitting lighting energy types such as candles and kerosene lanterns with average CO emissions of 2 ppm and 1 ppm respectively were not considered because their emissions are very minimal to endanger human health.

Emission from lighting devices

There are varying CO emission levels from the 'dirty 'alternative lighting fuel households use in times of power outage. As shown in Plate I, a candle stick measuring 19cm (length); 1.5cm (base diameter) and 1cm (tip diameter) burned for 3 hours in an enclosure (windows and door closed) with average carbon monoxide concentration of 2 ppm.

With the same specification of candle but in an opened enclosure (windows and door opened), the candle burned for 2 hours 45 minutes and yielded zero emission. The implication is that candles, in terms of carbon monoxide emission are safer than generators that are used inefficiently though they are rarely used because of the low illumination and the risk of fire hazard if not administered properly.

Similarly, kerosene lantern used by 1.3% of the households observed for one hour emits an average carbon monoxide emission of 1 ppm.

Plate I: Measuring CO Emission from Candle
Source: Authors 'field work, 2018.

Plate II: Observing CO level

Generators come in various sizes and capacities but the commonest in use is the TG950 model (I pass my neighbour) because it is more affordable and portable to most urban residents. Also of interest is its operating principle regarding emission

because engine oil is added to the petrol which aggravates emission of carbon monoxide. Equally, its size makes it flexible position-wise as it can be adjusted at will. For example, bringing it closer or even within the dwelling corridors and veranda during adverse weather conditions such as rain.

The research adopted two scenarios to represent the generator operating position within and outside dwellings. Observing CO level in an indoor environment (worst-case scenario) was done in a 400 m2 hall where a TG950 model (I pass my neighbour) generator was used alongside measuring tape and a gas detector (Plate II).

The generator is placed at the centre of the hall and the readings were recorded at an interval of one meter up to ten meters distance from the generators four sides. This was done to observe possible variations in the readings. The measurement range of 1 - 10 meters as depicted in Table 2 was based on the assumption that generators placed above 10m has minimal adverse impact in terms of air pollution.

Table 2: Varying carbon monoxide concentration from a generator in an enclosure

Distance (m)	Side A	Side B	Side C	Side D	Avg conc/dist (ppm)
1	125	25.2	62.4	87.2	74.95
2	68.6	20.4	59.4	88	59.1
3	50.6	16	53.2	99	54.7
4	50.4	26.4	58	110.2	61.25
5	51.8	27.6	57.8	108.8	61.5
6	21.4	29.6	58.6	114.2	55.95
7	4	32.4	69.2	118.6	56.05
8	4	37.2	65.2	120.2	56.65
9	6	36.6	72.6	124.2	59.85
10	24.8	39	60.2	123.8	61.95
Avg conc/ side	40.66	29.04	61.66	109.42	60.19

Source: Authors 'field work, 2018.

As shown in Table 2, it was discovered that at one meter away from the exhaust pipe side, the CO concentration was highest at 125 ppm and the side adjacent to the exhaust pipe has the overall highest CO level. The mean emission is observed to be approximately 60 ppm.

For the best-case scenario (out-door), the generator is placed with the exhaust pipe directed away from building openings (windows and doors) at intervals of one meter up to ten meters and gas detector readings indoors were recorded. The result of the observation in both best- and worst-case scenarios (out-door and in-door) at distances of one meter to ten meters from the source point is shown in Figure 1. In the same way, for in-door environment, the generator was at the centre of the hall from where measurements were taken from the exhaust pipe direction, opposite and both adjacent directions. The indoor environment result is the average of the results from the four directions of the source point.

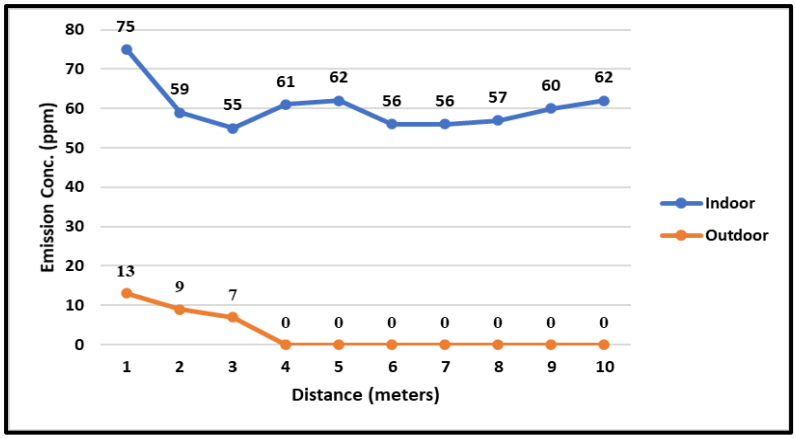

Figure 1: Average concentration levels at various distances in both scenarios
Source: Authors 'field work, 2018.

Apart from indicating the various concentration levels at various distances in both scenarios, Figure 3 also shows that from the source point in an enclosed environment, the concentration fluctuates as the distance increases but rises at the extreme (wall barrier). It was also observed that wind (speed and direction) influences emission concentrations levels. The indoor experience implies that operating generators within the buildings is a health risk because emissions within the dwelling build up to dangerous levels.

Generator operating positions and distances

Portable Petroleum Electricity Generators (PPEG) are operated from varying positions and distances during power outages. From the survey, the generator operating positions were identified and classified in Table 3 as follows: Generator house – enclosure purportedly built for generators to be operated from; outside the building (dwelling) – open operating position outside the dwelling from varying distances dependent on the convenience of that position and; within the building – operating positions under the same dwelling roof such as corridors, underutilized rooms, verandas, balconies, in-built garages and in tangent to dwelling walls.

Table 3: Generator operating position

Generator Position	Frequency	Percentage
Generator house	59	23.6
Outside the Building	148	59.2
Within the building	43	17.2
Total	250	100

Source: Authors 'field work, 2018.

Out of the generator users, 23.6% operate their generators from generator house, 17.2% within the dwellings such as in the corridors, verandas, lobbies and unused rooms within the building while 59.2% operate PPEGs outside the dwellings from various distances. It is worthy of note that distance wise, those PPEGs operated from purposeful generator houses are assumed to be safe in terms of indoor pollution while those operating within the buildings are assumed to be at zero distance. Generators operated within and outside the dwellings apart from generator houses are the bases for the analysis.

Based on the worst-case scenario observations stated earlier, 17.2% of the households that operate their PPEGs within the dwellings are at risk of greater exposure to carbon emission from generating plants. From the enclosed environment, carbon monoxide concentration observed from the study recorded an average of 60 ppm. For a minimum of 30 minutes exposure with such concentration, symptoms of headache and dizziness would be experienced by the occupants and would tend to a hazardous level for 8 hours exposure (Goldstein 2008; Struttmann et al., 1998). This result suggests that 66.4% generator using households representing 41.5% of the entire households in the study area are exposed to hazardous level of PPEG induced indoor pollution.

The observations further revealed that generators placed at 4 meters away from dwellings with other conditions met, zero (0 ppm) carbon monoxide concentration was recorded. It is imperative to reiterate the conditions to include; air/wind influence, exhaust pipe directed away from dwelling openings and against the wind direction. These conditions especially the wind influence in terms of speed and direction are major constraints to the record taking. This was addressed by taking measurements at intervals and eventually using their average.

In summary, Figure 2 reveals that 66.4% of the generator using households are at great risk of exposure to indoor pollution as they operate their PPEGs within the observed generator operating distance of less than or equal to 4 meters. This represents 41.5% of the entire households in the study area.

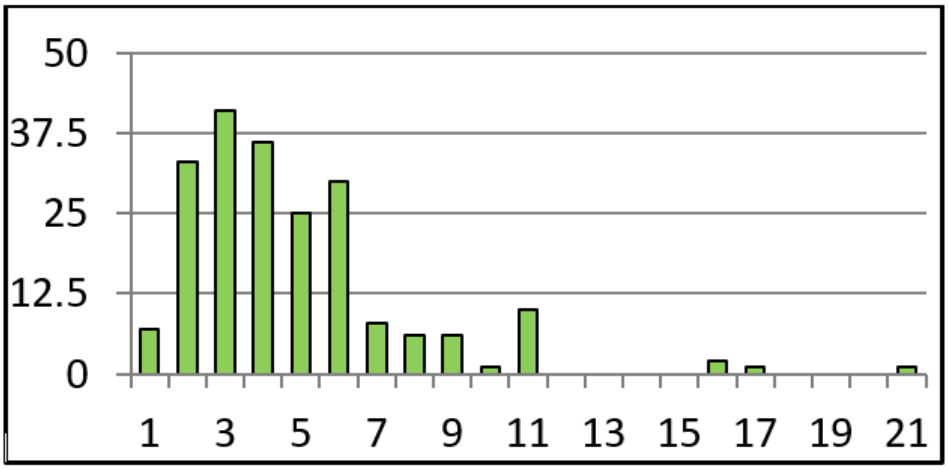

Figure 2: Dangerous Generator Operating Distance
Source: Author's field work, 2018.

Generator use characteristics as observed by the survey vary as such variations are indicators of how safe or not households are in terms of emission exposure with reference to generator operating distances outside the dwellings. The analysis is based on the observed safe operating distance of 4 meters in Minna metropolis. The study discovered that 66.4% of the households using generator as their primary lighting energy type are at risk of emission exposure based on 4 meters generator safe operating distance from houses.

CONCLUSION AND RECOMMENDATIONS

Promoting access to electric power in particular is a very important dimension to consider in enhancing households 'access to energy. Poor accessibility to modern energy is the main rationale for households 'reliance on pollutant emitting domestic lighting energy types that endangers their health through indoor pollution. It could be deduced that neighbourhood quality and liveability is undermined by the extensive and high level of pollution. Abnormal use of PPEGs such as its proximity to building openings, faulty and subserviced plants, positioning the exhaust pipe against wind direction also aggravates morbidity rate of households through indoor pollution.

In order to improve both human and environmental health likewise reducing dependence on emission generating domestic lighting energy sources in Minna metropolis, the study recommends operating generators above 4 meters away from users and dwellings and ensuring compliance to reduce pollutants concentration. Also, enlightenment on the dangers of exposure to carbon monoxide is imperative likewise encouraging installation of affordable carbon monoxide detector(s) in homes. This alerts the households when carbon monoxide level exceeds safe limit of 9 ppm.

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