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Potential Climate Change Impacts on Environmental Health Services: Perspectives from a Developing Country

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Abstract Climate change can be seen as a threat to sustainable development by undermining global poverty alleviation efforts and seriously impacting on successfully achieving the outcomes as envisaged by the Millennium Development Goals. There also exists severe implications for food security, clean water, environmental health and human settlements as the potential impacts of climate change bears much significance especially for the sustainable development of developing countries, such as South Africa. Therefore the role of the Environmental Health sector which is a key component in the protection of public health in South Africa, needs re-addressing as regards the potential impacts of climate change on Environmental Health Services. These potential impacts necessitates forward thinking on what adaptation measures should be considered by this sector, staffed primarily by Environmental Health Practitioners (EHPs), and how can these then be implemented proactively – given that in the South African context, EHPs have a Government regulated scope of practice that covers fourteen key job functions. Therefore, this article for each key job function, considers potential impacts of climate change followed by a discussion of possible solutions and challenges. However, despite adequate awareness on climate change and its impacts, it is evident that there are many challenges, inclusive of immense financial, technical and human resource constraints, still ahead. Therefore, a systematic approach by EHPs to assess, prevent and control climate change impacts and other interacting public health issues is vital and will be crucial to protect the health of affected populations in the future.

Keywords: *climate change, potential impacts, environmental health, developing country, south africa*

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1. Introduction

According to the South African National Climate Change Response Strategy [1], there was an urgent need to acknowledge the overall vulnerability of South Africa to climate change impacts, including the potential impact(s) on the environmental health sector. Environmental health addresses all the physical, chemical, biological and related factors external to a person and impacting on behaviours. [2] It also encompasses the assessment and control of those environmental factors that can potentially affect health so as to prevent disease and create health-supportive environments. These potential impacts necessitates forward thinking on what adaptation measures should be considered by this sector [3], staffed primarily by Environmental Health Practitioners (EHPs), and how can these then be implemented proactively – given that in the South African context, EHPs have a Government regulated scope of practice that covers fourteen key job functions.

These job functions are, namely: 1) Water Quality Monitoring, 2) Food Control, 3) Waste Management and General Hygiene Monitoring, 4) Health Surveillance of Premises, 5) Surveillance and Prevention of Communicable Diseases, excluding immunisations, 6) Vector Control Monitoring, 7) Environmental Pollution Control, 8) Disposal of the Dead, 9) Chemical Safety, 10) Noise Control, 11) Radiation Monitoring and Control, 12) Port Health, 13) Malaria Control and 14) Control and Monitoring of Hazardous Substances. Therefore, this article for each key job function, considers potential impacts of climate change followed by a discussion of possible solutions and challenges.

2. Scope of Practice for the Environmental Health Practitioner

2.1. Water Quality Monitoring

Changes in hydrological processes will affect raw water supply in catchment areas of poor communities and/or developing countries thereby impacting on the supply of potable water. [4] Further, variations in temperature of surface waters will affect raw water quality in terms of pH, dissolved oxygen, organic and inorganic pollutants. [5]

This poor raw water quality will impact greatly on water treatment plants and its associated processes. Additionally, the performance of sewer systems and load capacities [6] maybe negated and can increase storm water run-off and sewer overflow which can lead to an increase in E-coli and other pathogen levels which in turn, may cause a raise in waterborne diseases. [7]

To combat these potential impacts, an upgrade of existing water treatment and sewerage works in terms of capacity, should be considered in the South African Government's infrastructural planning and budgeting, and new technology should be piloted to boost disinfection processes at the treatment works. An increased frequency of raw water source monitoring for microbiological and chemical analyses will be essential in order to decrease the advent of disease incidence. To this end, strategies should be adopted to increase financial, human resource and intellectual capacity in environmental health laboratories so that timely and effective analyses are undertaken. However, due consideration must be taken of budget constraints within rural and smaller municipalities. We must also be aware that by-products from disinfection processes e.g. tri-halomethanes, can be carcinogenic. [5]

2.2. Food Control

Feed-related issues (raw materials, pasture, silage, storage and manufacturing of compound feed) and animal health are the critical factors that can potentially increase the incidence of food safety hazards. [8] Freshwater containing runoff with pathogens, chemical contaminants and pesticide residues caused by heavy precipitation can contaminate seafood and irrigated crops. [9] Alternatively, drought will cause stressful conditions leading for example, to aflatoxin formation by moulds on harvested crops. Climate change will cause monitoring systems, focused on food safety hazards, to miss - or pick up, with delay – the occurrence of new hazards or known hazards in food products in which they previously did not occur. [10] Climatic factors therefore will contribute to the sources, growth, survival and modes of transmission of pathogens in the environment and the microbial ecology of the food matrix, thereby leading to an increase in microbiological food contamination and associated food borne diseases. [11]

To counteract these potential impacts, there needs to be an improvement in animal husbandry practices e.g. healthy herds and avoiding heat exposure (animal stock). Proper storage of feed e.g. waterproofing of silos and avoidance of herd overstocks should also be advocated. Proactive early warning systems of weather-driven food safety problems that are presently known should be devised and Hazard Analysis Critical Control Point (HACCP) principles should be made compulsory in all food sectors. Note should be taken though that food safety warning systems e.g. HACCP are at an infancy stage in developing countries and to date, the peanut industry is the only food sector in South Africa to be regulated by HACCP.

2.3. Waste Management and General Hygiene Monitoring

Although limited data hinders the development of projections for future waste trends, it is considered that most waste streams will increase over the next decades amidst constant climate change [12] and more especially in developing countries. Increases in precipitation will influence hazards and risks on landfill sites i.e. contamination of groundwater by leaching, and inaccessibility will lead to non-approved and non-regulated disposal methods. [13] Extreme weather events will disrupt the efficient transport of health care risk waste resulting in overflows at the source e.g. at hospitals, while impacts on sanitation at low cost housing developments and informal settlements may result in damage to ventilated improved pit latrines and overflowing pit latrines. Extreme fluctuations in temperature and precipitation will lead to increased animal deaths due to disease; hence carcass handling and disposal challenges are envisaged.

In terms of mitigation potential of the waste sector, waste prevention (through improved efficiency in materials use in industrial production, incentives to generate products with enhanced recycling capability, and cleaner production), as well as reuse and recycling, also assisted by policies such as the extended producer responsibility, are believed to be capable of yielding considerable savings in greenhouse gas emissions. [14] It is also suggested that alternate treatment technologies be considered inclusive of a shift from land-filling to waste incineration and alternatively, other avenues should be explored for the mechanical, biological and thermal treatment of waste e.g. microwaving. [15] A major challenge that currently exists is that although the cradle to grave approach is advocated globally, the focus on waste management is not a priority, especially in developing countries where poverty and disease is at the forefront. Education campaigns only appear successful in affluent communities.

2.4. Health Surveillance of Premises

Urbanisation will grow with climate change resulting in substandard housing due to illegal building work (without building plans) and overcrowding. [16] Buildings contribute to climate change, influence transportation and affect health through the materials utilized, decisions about sites, electricity and water usage and landscape surroundings. [17] Further, extreme weather events can cause structural damage to buildings therefore compromising lighting, ventilation and encouraging dampness. [18] Public health nuisances will also increase with these denser human settlements e.g. illegal activities, keeping of poultry/animals, waste water discharges and indiscriminate dumping. Extreme weather events will result in displacement of people who may need to occupy temporary accommodation hence the added risk of disease, insufficient water and inadequate sanitation supplies.

Therefore, there needs to be an added impetus on the part of the Environmental Health sector to ensure municipal law regarding occupation of buildings for residential purposes, is enforced. It is critical to budget for and prioritise housing shortages, including consideration for low cost housing developments. It is suggested that the use of sustainable, local, and/or recycled construction materials and reuse of older buildings be increased [17] and increased heating and cooling efficiency through site orientation, insulated windows, green roofs and natural

ventilation be implemented. However, the current key challenge is that tenant farming is rapidly increasing in all cities throughout South Africa and local authorities are lacking capacity to effectively deal with this phenomenon.

2.5. Surveillance and Prevention of Communicable Diseases, Excluding Immunisations

Climate change will make the control of many climate-sensitive health determinants and outcomes more difficult. [19] Since the health determinants and outcomes that are projected to increase with climate change are problems today, in most cases the primary response will be to enhance current health risk management activities. However, that is unlikely to be sufficient to address changing disease patterns and new health risks. Climatic factors can impact on the epidemiology of various infectious diseases. g. warm-malaria, cold–influenza, dry–meningococcal meningitis, wet–cryptosporidiosis. [20] Human activities can then influence infectious disease transmission rates e.g. warm ambient temperatures lead to use of air-conditioning systems which can in turn harbour and spread the bacillus responsible for Legionnaires' disease. Also, in order to be transported over the relatively large distances from one host to another, many microbes may be passively borne through moving air or water.

Health policies and programs will need to include current and projected climate-related risks in order to maintain and enhance current levels of prevention and control. Government agencies will also need to monitor and reduce current health burdens. Strengthening current health protection would not only save lives but would increase the capacity to address any future risks due to climate change. The implementation and evaluation of disease early warning systems to provide public health officials and the general public with as much advance notice as possible about the likelihood of a disease outbreak in a particular location, thus widening the range of feasible response options, should be advocated sooner rather than later. However the focus on existing health burdens is challenging in itself, as poverty has a stranglehold in the developing world and existing epidemiology studies have gaps in terms of trends, projections and emerging diseases [19] that make future planning difficult.

2.6. Vector Control Monitoring

Climate change will increase the number of disease vectors, vector biting rate and vector development rate as changes in temperature and precipitation increase. [21,22,23] Mosquito breeding and prevalence will also increase due to heavy rainfall and stagnant water. [24] As the world continues to become a global village, infected mosquitoes may be transported via air, rail, road and ship with a potential to increase Malaria incidence globally. [23] In South Africa, as rural populations and previously disadvantaged communities continue to leave their homes for the city, in search of a better, more empowered life, there will be a continual mushrooming of informal settlements. This increased concentration of people leads to bigger human settlements where food sources for vectors can be numerous and waste collection and disposal sites may not be adequately provided. This can lead to an increase in the rodent population.

Additionally, in formal settlements, extreme weather events can damage buildings. Demolitions and new building work generate rubble which is an ideal breeding ground for rodents. As a precautionary measure, vector control programmes, training of staff on control measures and mosquito species identification, and the proper and safe use of chemicals/pesticides/larvacides/ rodenticides should be intensified. Focussed health education programmes should be rendered in communities where early identification of breeding habitats of vectors is a priority. The challenges that arise are that areas most at risk may be inaccessible due to their geographic location and effective vector control is expensive in terms of chemicals to be used.

2.7. Environmental Pollution Control

Extreme weather events will be classified as natural disasters in many instances and will often be in the form of tropical cyclones, floods, landslides, hail, lightening, tornadoes – all of which will increase the mortality and morbidity rates and contribute to human displacement. [25] Human activities and displacement in relation to corresponding climatic changes will subsequently increase the use of public or private transportation and place a demand on the increased use of electricity [26] which in South Africa, is primarily sourced from coal driven power stations. There will be a related increase in the emission of ambient air pollutants (unless alternative sources of clean energy are sourced) and other pollutants that contaminate land and water resources. Industrial output and its corresponding emissions will increase to meet demand and if not properly monitored by public officials, can increase environmental pollution which can have serious health consequences on workers and surrounding communities alike. Additionally, on land, an increase in the number of informal settlements (while also impacting on the South African economy by increasing informal activities) will cause environmental pollution to rise. [27]

It is therefore prudent to realistically devise and adopt disaster management plans at local, regional and national levels and bring all stakeholders to the table inclusive of collaborating government departments, industry, community representatives and the media. Extreme event risk modelling can make a significant contribution within the climate change adaptation context, and makes a case for building capabilities in this field. [25] Inter-sectorial collaboration though, is currently lacking within disaster management agencies and there is a need for more research in disaster risk modelling.

2.8. Disposal of the Dead

Increased mortality rates due to natural disasters and disease will lead to mortuaries being unable to cope due to space and refrigeration constraints. Additionally, insufficient burial space in cemeteries may raise the likelihood of mass graves leading to water logging of existing graves when it rains. Non-regulated burials in the backyards of residential areas are more likely as this is also a cultural norm in some South African ethnic groups. However this unsolicited practice can cause soil pollution, odours and contamination of ground water. [28] An

increase in cremations will increase air pollution especially if there are inadequate and defective cremators and cultural cremations. There may be a subsequent increase in the number of illegal and unregistered undertakers.

Plans therefore need to be considered as follows: a) When government rolls out the yearly budget, it needs to cater for an increase in cold room and human resource capacities at all government mortuaries; b) Encourage and educate undertaker associations; c) Identify appropriate burial grounds for future use and d) Consider water proofing of graves. However financial constraints and other health priorities may hinder the effective management of this function.

2.9. Chemical Safety

Safety standards within the chemical industry will decrease, especially in developing countries as workers may be less qualified, under age and inexperienced. [29] This and increased adverse weather conditions can also be contributing factors to road accidents as most chemicals in South Africa are transported by road. As vectors and vermin increase due to climatic changes, more informal, unregistered fumigation companies may grow rapidly. Their use of pesticides can increase, leading to adverse safety precautions regarding storage, handling and application, and increasing occupational health and safety risks. In informal settlements, due to a decrease in temperature, paraffin usage will increase which can impact negatively on safety and environmental pollution.

To counteract the above, it is imperative that relevant industries fully embrace, adopt and evaluate induction and training programs on chemical safety. They should also consider employing qualified people for these specialised sectors who will be able to drive chemical tankers that are roadworthy. As an alternative to road transport, due consideration should be taken of using the rail transport which already exists throughout most of South Africa. However, there exists the possibility that industry will deviate from labour laws due to cheap labour being more economically favourable where fore. g. contract workers, unskilled, minors, illegal immigrants are employed. Emphasis may be more on productivity and profits, rather than safety.

2.10. Noise Control

The effects of climate change on noise control can be severe. The increased demand for technology for climate change adaptation can mean the advent of more industries been built where the machinery and its accompanying processes can elevate community and occupational noise. [30] Potential solutions could place emphasis in the occupational health setting, on strict use of personal protective equipment by workers, education on side effects, benefits of adhering to control measures and adherence by the industry concerned, to exposure limits. Also, focus should be on engineering and using machinery and equipment that reduces sound/noise to acceptable levels. It is important to note though, that in South Africa, due to the high levels of humidity and heat, employees generally find hearing protection an inconvenience and uncomfortable to work with and therefore seldom use it, even if freely provided.

2.11. Radiation Monitoring and Control

As explained elsewhere in this article, climate change will increase morbidity rates. This may necessitate an increase in x-rays by the medical sector and the subsequent production of radiation waste materials. Due cognisance should then be taken of how this waste is collected and disposed of safely with minimal risk to the worker and the environment. Further, due to increased frequency in inclement weather, there could be an increase in road accident rates of radioactive waste tankers/vehicles. During the waste disposal process, the increased use of coal as an energy source can cause uranium and thorium to become concentrated in the fly ash because these products are not fully incinerated and could potentially be inhaled. [31] Additionally, there also exists an increase and demand for nuclear energy and the disposal challenges and safety associated with radioactive waste. Extreme weather events could damage power lines leading to non-ionising radiation hazards.

As a precautionary measure, all medical centres that have x-ray facilities should ensure that they are contracted to registered hazardous waste companies and that all legalities are followed from source to final disposal. Also, due consideration should be given to the usage of alternate transportation modes for e.g. rail. The challenges which currently exist are that drivers of these vehicles often act irresponsibly and there is often illegal dumping of this waste to save on road toll fees and time constraints.

2.12. Border's Health Surveillance (In South Africa, *a.k.a* Port Health)

Natural disasters in neighbouring countries can lead to the displacement of people who may then flee their countries and enter South Africa as illegal immigrants, bringing with them for e.g. imported diseases like Malaria. Further, disease vectors like mosquitoes and rodents can enter South Africa on board ships and planes. An added concern is that vaccination programmes for seafarers may not be effective due to the emergence of immune strains of pathogens. Climate change will also impact on the global economy and can influence importation of substandard foodstuffs, labelling irregularities and exacerbate illegal entry thereof where trans-boundary movement of hazardous cargo can increase by bypassing or avoiding inspection.

Therefore mitigating steps should be put in place to secure and strengthen control at all ports of entry with possible human resource assistance from the South African Department of Defence. Devising and adopting more stringent disease surveillance measures at border posts e.g. vaccination records of immigrants, should be piloted and vector control on vessels intensified. An added control measure would be to introduce surveillance on departure of vessels as well. The challenge that is however prevalent is that in the case of Malaria, imported cases cannot be detected in the human host at border posts as there is no capacity for this to be undertaken.

2.13. Malaria Control

The incidence of Malaria will increase due to an increase in rainfall and in the mosquito vector. Global warming plays a significant role because the malaria

parasite development expands in areas with higher temperature. [32] Weather conditions will hamper vector control applications like residual spraying and displaced immigrants can increase the number of imported cases. Malaria's impact on public health will be compounded by its high economic costs, such as expenditure on prevention and treatment by households and by health services. [33] Surveillance and control measures to affected areas will be hampered due to geographic inaccessibility and inclement weather. Therefore, climate change needs to be integrated into Malaria policies, strategies and plans [33] with a focus on environmental management. [34] However, due cognisance must be taken of the fact/challenge that there is a lack of reliable quantitative and qualitative data for malaria projections.

2.14. Control and Monitoring of Hazardous Substances

Climate change will impact on all transportation modes and this will lead to accidents, derailments and spillages. There also exists the likelihood of empty contaminated containers being discarded at informal settlements and these then be used by these disempowered communities for food and water storage. Technology demands to deal with climatic impacts through new industrial processes and the manufacturing of new substances may not be properly treated and dealt with. [30] Resultant labelling inadequacies may not be able to classify and determine safety procedures where for e.g. increase in temperature can be hazardous to storage conditions, especially if substances are flammable.

A possible way forward is to ensure continued transport worthiness of all transportation vessels and implement regular training and safety awareness programmes for all involved in the control and monitoring of hazardous substances. All transporters must be contracted to hazard waste recovery/clean-up companies. All manufacturers/dealers/retailers should ensure a cradle to grave approach with decanting of hazardous substances being discouraged. In South Africa, control of hazardous substances is presently a function of provincial departments of health who lack resources to effectively perform this task. This should be cascaded to local authority level.

3. Conclusion

Despite adequate awareness on climate change and its impacts, it is evident that there are many challenges, inclusive of immense financial, technical and human resource constraints, still ahead. The piloting and implementation of workable and feasible solutions, inclusive of solutions suggested in this article, and the undertaking of further research in this area, is urgently required. Therefore, a systematic approach by EHPs to assess, prevent and control climate change impacts and other interacting public health issues is vital and will be crucial to protect the health of affected populations in the future. It is envisaged that this paper can form a framework for climate change mitigation in terms of environmental health services in South Africa and as such, be adopted as policy within environmental health departments at local and provincial government levels and also contribute to climate change planning in other developing countries.

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Statement of Competing Interests

The authors have no competing interests.

References

[1] South Africa, Department of Environmental Affairs and Tourism, *South African National Climate Change Response Strategy*. Pretoria: Government Printer, 2004.

[2] Environmental Health. World Health Organization (WHO). Available from: http://www.who.int/topics/environmental-health/en/ [Accessed 2nd May 2014].

[3] Forest, S, and Feder, M.A, *Climate Change Education Goals, Audiences, and Strategies: A Workshop Summary*, National Academies Press. 2011. Available from: http://site.ebrary.com/lib/durbanut/Doc?id=10531097&ppg=13 [Accessed 18th March 2014].

[4] Fung, F., Lopez, A. and New, M, *Modelling the Impact of Climate Change on Water Resources*, Wiley-Blackwell, Hoboken, USA, 2010.

[5] Delpla, I., Jung, A.V., Baures, E., Clement, M. and Thomas, O., "Impacts of Climate Change on Surface Water Quality in relation to Drinking Water Production," *Environment International*, 35. 1225-1233.2009.

[6] Smith, J, *Climate Change and Water: International Perspectives on Mitigation and Adaptation*, American Water Works Association, Denver, CO, USA, 2009.

[7] Selendy, J. M. H., *Water and Sanitation-Related Diseases and the Environment: Challenges, Interventions, and Preventive Measures*, Wiley-Blackwell, Hoboken, USA, 2011.

[8] Van der Spiegel, M., Van der Fels-Klerx, H.J. and Marvin, H.J.P, "Effects of Climate Change on Food Safety Hazards in the Dairy Production Chain," *Food Research International*, 46. 201-208. 2012.

[9] Marques, A., Nunes, M.L., Moore, S.K. and Strom, M.S, "Climate Change and Seafood Safety: Human Health Implications," *Food Research International*, 43. 1766-1779. 2010.

[10] Marvin, H.J.P., Kleter, G.A., Van der Fels-Klerx, H.J., Noordam, M.Y., Franz, E., Willems, D.J.M, and Boxall, A, "Proactive systems for early warning of potential impacts of natural disasters on foodsafety: Climate-change-induced extreme events as case in point," *Food Control*, 34. 444-456. 2013.

[11] Tirado, M.C., Clarke, R., Jaykus, L.A., McQuatters-Gollop, A. and Frank, J.M, "Climate Change and Food Safety: A Review," *Food Research International*, 43. 1745-1765. 2010.

[12] Hester, R., Harrison, E. and Roy, M, *Environmental and Health Impact of Solid Waste Management Activities*. The Royal Society of Chemistry, Cambridge, 2012.

[13] Wasman, J, "Waste and Climate Change: Can appropriate management strategies contribute to mitigation?" *Waste Management*, 32. 1501-1502. 2012.

[14] Polettini, A., "Waste and Climate Change: Can appropriate management strategies contribute to mitigation?" *Waste Management*, 32. 1501-1502. 2012.

[15] Monni, S., "From Landfilling to Waste Incineration: Implications on GHG emissions of different actors," *International Journal of Greenhouse Gas Control*, 8. 82-89. 2012.

[16] Booth, C., Hammond, F., Lamond, J, and Proverbs, D, *Solutions for Climate Change Challenges in the Built Environment*. Wiley-Blackwell, USA, 2011.

[17] Younger, M., Morrow-Almeida, H.R., Vindigni, S.M. and Dannenberg, A.L, "The Built Environment, Climate Change, and Health Opportunities for Co-Benefits," *American Journal of Preventive Medicine*, 35 (5). 517-526. 2008.

[18] Banta, J, *Extreme Weather Hits Home: Protecting Your Buildings from Climate Change*, New Society Publishers, Canada. 2007.

[19] Ebi, K.L., "Managing the changing health risks of climate change," *Environmental Sustainability*, 1. 107-110. 2009.

[20] National Research Council, Committee on Climate, Ecosystems, Infectious Disease, and Human Health, *Under the Weather: Climate, Ecosystems, and Infectious Disease*, National Academic Press, USA, 2001.

[21] Little, S.E., "Future challenges for parasitology: Vector control and one health in the Americas," *Veterinary Parasitology*, 195. 249-255. 2013.

[22] Banu, S., Hu, W., Guo, Y., Hurst, C. and Tong, S., "Projecting the impact of climate change on dengue transmission in Dhaka, Bangladesh," *Environment International*, 63. 137-142. 2014.

[23] Kilpatrick, A.M. and Randolph, S.E. "Drivers, dynamics, and control of emerging vector-bornezoonotic diseases," *Lancet*, 380. 1946-1955. 2012.

[24] Arjunan, N., Kadarkari, M., Pari, M., Thiyagarajan, N. and Kumar, S., "Impact of climate change on filarial vector, Culex quinquefasciatus and control using bacterial pesticide, spinosad," *Asian Pacific Journal of Tropical Disease*, 4 (1). 87-91. 2014.

[25] Palutikof, J, *Climate Adaptation Futures*, Wiley-Blackwell, USA, 2013.

[26] Holgate, C., "Factors and Actors in Climate Change Mitigation: A Tale of Two South African Cities," *Local Environment*, 12 (5). 471-484.2007.

[27] Maslin, M, *Global Warming: A Very Short Introduction*, Oxford University Press, UK. 2004.

[28] Masters, L. and Duff, L, *Overcoming Barriers to Climate Change Adaptation Implementation in Southern Africa*, Africa Institute of South Africa, SA, 2012.

[29] Vinodkumar, B. and Bhasi, M., "Safety climate factors and its relationship with accidents and personal attributes in the chemical industry," *Safety Science*, 47. 659-667. 2009.

[30] Satarkar, A, *Guidelines of Environmental Pollution and Control*, Global Media. 2008. [E-book] Available from: http://site.ebrary.com/lib/durbanut/Doc?id=10415116&ppg=72 [Accessed 5th March 2014].

[31] Wilkinson, P, *Environmental Epidemiology*, McGraw-Hill Education, GBR, 2006.

[32] Shaw, R., Pulhin, J, and Pereira, J, *Community, Environment and Disaster Risk Management, Volume 5: Climate Change Adaptation and Disaster Risk Reduction: An Asian Perspective*, Emerald Group Publishing, 2010. [E-book] Available from: http://site.ebrary.com/lib/durbanut/Doc?id=10445342&ppg=439[Accessed 10th March 2014].

[33] World Bank, *Intensifying the Fight Against Malaria: The World Bank's Booster Program for Malaria Control in Africa*, World Bank Publications, 2008. [E-book] Available from: http://site.ebrary.com/lib/durbanut/Doc?id=10264158&ppg=30 [Accessed 10th March 2014].

[34] World Health Organization, *World Malaria Report*, World Health Organization (WHO), 2009. [E-book] Available from: http://site.ebrary.com/lib/durbanut/Doc?id=10411816&ppg=14 [Accessed 10th March 2014].