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Status of Indoor Air Pollution in Tanzania, a Review

J. M. KIHILA*

ABSTRACT

Indoor air pollution is one of the existing global environmental problems. Its impacts seem to be more apparent in developing countries but unfortunately the information about the magnitude of the problem is scarce. Depending on the type of pollutants and the exposure duration, indoor air pollutants cause significant damage to public health. Among the several known sources, use of biomass for cooking has been reported to be the major contributor of indoor air pollution. For developing countries, it follows in this case that women and children who spend most of their times indoor are the most vulnerable group. Strategies to protect the public against the air pollutants need to be sought and implemented.

In this paper general information on indoor air pollution, the magnitude of the problem globally and in developing countries, as well as the general situation in Tanzania are reported. Further information for Tanzania especially on the risk behaviours leading to indoor air pollution, the possible techniques that can be employed to reduce the magnitude of the problem and areas for further research are pointed out. The need for more research to inform the policy and decision making processes is underscored. Research areas to be pursued for generating knowledge to help the decision maker and the public in general on the best ways to reduce indoor air problems are specified.

Keywords: Indoor air pollution, biomass energy, cooking, developing countries, Tanzania

INTRODUCTION

Indoor air pollution is one of the global problems with a significant contribution to the global disease burden. Yet, little has been documented on the various aspects of indoor air pollution especially for developing countries which seem to be the most affected. Indoor air pollution is usually noticeable when the indoor air quality is affected by air pollutants. According to EPA, Indoor air quality refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants (EPA, 2015). It can also be defined as the totality of attributes of indoor air that affect a person's health and well being or the presence or absence of air pollutants in the building (The health of Washington State, 2002). Other scholars define indoor air quality as occupied space which a substantial majority of occupants express no dissatisfaction and in which there are not likely to be known contaminants at concentrations to cause significant health risk (Gurjar *et al.*, 2010). Generally, indoor air suitable for the inhabitants must have its parameters within the permissible limits as stipulated in the relevant quality standard. When the levels of the standards are exceeded indoor air is said to either contaminated or polluted. Therefore indoor air pollution is the presence of air pollutants at levels that exceed the stipulated levels in the relevant standard. The aim of indoor air quality standards is to protect human health and bring comfort to the people who stay in the indoor environment.

While indoor air pollution affects the quality of indoor air, clean air remains the basic requirement of life. The quality of air inside homes, offices, schools, day care centres, public buildings, health care facilities or other private and public buildings where people spend a large part of their life is an essential determinant of healthy life and people's well-being (WHO, 2010). Indoor exposure to air pollutants can cause very significant damage to health (Oguntoke *et al.*, 2010; WHO, 2010)

*Dr. J. M. Kihila is a Research Fellow in the Institute of Human Settlement Studies (IHSS) at Ardhi University, Dar es Salaam, Tanzania. His contact address is P.O. Box 35124 E-mail: kihilaj@gmail.com

and in this regard, problems of indoor air quality are recognized as important risk factors for human health. This is due to the fact that most people spend a substantial proportion of their time in buildings (Brasche & Bischof, 2005; Yu & Crump, 2010) majority of which being residences, day-care centres, retirement homes and other special environments (Oguntoke, et al., 2010; WHO, 2010).

The health effects arising from indoor pollution seem to be more significant in substandard housing than in improved housing (Rauh et al., 2008). Literature indicates the presence of significant number of substandard houses in developing countries than in developed ones which implies that the problems related to indoor air pollution may be more pronounced in those countries (Cohen, 2004). This makes the people within the developing countries the most vulnerable. Studies also indicate that the most affected groups are women and children because they spend most of their time indoor (Jackson, 2009).

The problem of indoor air pollution is ranked as the 8th important risk factor that accounts for about 2.7% of the global disease burden and about 3.7% of the same in developing countries. Indoor air pollution has also been reported to be responsible for over 1.6 million deaths a year, resulting from pneumonia, respiratory diseases and lung cancer (Moturi, 2010; WHO, 2005). Chronic exposure to biomass smoke is one of the most important environmental and public health problems and is considered to be the major contributor to indoor air pollution in developing countries (Kurmi *et al.*, 2014). In the same countries, women who use biomass for cooking and children who attend to the fires or stay close to their mothers during cooking are the most affected and this could be the reason for the problem to be more serious in those countries (Fullerton *et al.*, 2008). Studies show that more than 60% of the populations in most of the developing countries depend on biomass as a source of fuel for cooking (Clough, 2012). For example, populations depending on biomass as source of fuel for cooking has been shown to be about 96% in Tanzania (Clough, 2012; Pesambili et al., 2003), 93% in Uganda (Tumwesigye *et al.*, 2011), 81% in Kenya (Clough, 2012), 60% in South Africa (Oguntoke, et al., 2010), 66.8 in Zimbabwe (HIVOS) and 80% in Zambia (SNV, 2013). This indicates that biomass dependence for cooking is high and that more research on indoor air pollution is the most pertinent to developing countries.

It therefore the goal of this paper to contribute in filling in the information gap by generating useful information that can guide scholars as they embark on research for finding solutions for addressing indoor air pollution. This paper provides a review of the general aspects of indoor air pollution and provides some specific insights about the problem in Tanzania and the possible areas for intervention.

Methodology

Literature search was mainly employed in conducting the review. Published literature on indoor air pollution was contacted, analyzed, synthesized, organized and documented accordingly. The literature was derived from various publications of reputable organizations; academic journals; national and global policies and guidelines; and books. Some of the key words used to search the information include "indoor pollution", "indoor pollutants", "indoor air Tanzania" to mention some. Various publications were retrieved from the available databases and repositories including Google Scholar, Elsevier, Taylor and Francis, African Journal online (Ajol) and Research gate.

General aspects of indoor air pollution

Sources of Indoor air pollution

The source of indoor air pollutants may be inside the building, or they may be transported into the interior space from the outside. Sources located indoors include building materials, combustion sources, furnishings, and pets. Emissions of organic gases from the sources are influenced with factors such as temperature and humidity but also with the age of the structure or furnishings (Vallero, 2007). Generally, construction materials and the composition of furnishings inside the building may give off or outgas pollutants into the interior airspace; natural gas for cooking and kerosene space heaters release NO and CO_2 even when operating properly; molds may grow in the ventilation ducts and be distributed throughout a building; radon from the soil can enter buildings through cracks in the foundation when the pressure inside is lower than in the soil (Gurjar, et al., 2010). On the other hand, the use of pesticides in the indoor environment releases pollutants that

may affect the human health when inhaled; also paints andvanishes can emit pollutants in the air and affect people especially when the indoor environment is inhabited with newly painted materials or walls.

The sources of indoor pollution can therefore be categorized as those arising from:

i. **Combustion:** when combustion of biomass is done indoor especially during cooking releases pollutants such as particulate matter (Vallero, 2007), PAHs (Lisouza *et al.*, 2011), Carbon Monoxide (Vallero, 2007), Nitrogen Oxide (Vallero, 2007), Nitrogen Oxide (Vallero, 2007), Volatile Organic carbons (Vallero, 2007). It can also generate sulphur dioxide if the material combusted contain sulphur (Gurjar, et al., 2010). Burning biomass has been pointed out as the major contributor to indoor pollution (Moturi, 2010; Smith et al., 2004).

ii. **Household products:** The household products such as pesticides can release pollutant in the indoor environment. The type of the pollutant released depends on the type of the pesticide used. Also carpets that are used indoors can harbor dust and volatile organic compounds. Volatile organic compounds can also be found in floor dust (Gurjar, et al., 2010; Nilsson, 2004).

iii. **Smoking:** Smoking produces environmental tobacco smoke (ETS) or second hand smoke in the air. The environmental tobacco smoke contains chemicals such as carbon monoxide, organic tars, PAHs, acrolein, arsenic, metal oxide particles, and other constituents of cigarette (Gurjar, et al., 2010; Peirce et al., 1997). Environmental tobacco smoke (ETC) can also release formaldehyde in the indoor environment (Gurjar, et al., 2010).

iv. **Construction materials:** Materials such asbestos, corrugated iron sheets, tiles and construction coatings may produce fumes or fine particles which are air pollutants. The pollutants released in the environment from this source include synthetic fibres and asbestos. Newly painted walls and materials as well as newly vanished furniture in indoor environment are able to release some pollutants into the air that can affect people (Gurjar, et al., 2010). Paints releases volatile organic compounds and vanish can produce formaldehyde in the indoor environment.

v. **Improper or poor ventilation:** It occurs when the indoor environment is not properly ventilated or the ventilation system is contaminated, some pollutants are released to the indoor environment and remain in there for a significant time. Some of the pollutants that are released or remain in indoor environment as a result of poor ventilation include particulate matter, the biological agents such as spores and molds that arise from pets, ceiling tiles and contaminated ventilation systems (Vallero, 2007).

vi. **Natural sources:** Some pollutants such as radon may exist in the indoor environment originating from the soil or the materials used for construction such as concrete (Gurjar, et al., 2010). If the soil or the construction materials comes from formations that are radioactive, then with time they may radiate to produce radon in the indoor environment.

Indoor air pollutants of concern and their health effects

Exposure to air pollution can cause a number of health problems. Air pollutants that are inhaled have serious impacts on human health affecting the lungs and the respiratory system. Different people are affected by air pollution in different ways. Poor and undernourished people, very young and very old, and people with pre-existing respiratory disease and other health problems are more at risk (Gurjar, et al., 2010). Major health effects associated with inhaling indoor air pollutants as well as the source of respective pollutant are summarized in Table 1. Despite the summarized problems of particulate matter (Table 1), the pollutant presents a series of common health problems as compared to other pollutants. The effects can be related to short or long term exposure duration. The problems associated with short term exposure include lung inflammatory reactions, respiratory symptoms, adverse effects on the cardiovascular system accompanied with frequent medication use; while the long term exposure effect include increased lower respiratory symptoms, reduced lung function in children and adults, increased chronic obstructive pulmonary disease, increased mortality and reduced life expectancy (Gurjar, et al., 2010).

Table 1: Major toxic pollutants of indoor air pollution and their health effects

Pollutant	***Major indoor sources***	***Possible health effect***	***Reference***
Particulate matter	Fuel/tobacco combustion, cleaning, fumes from food being cooked, e.g. from cooking oil	Bronchitis, asthmatic symptoms, allergies, inflammatory effects.	Bernstein et al., 2008; Palacios et al., 2014, Gurjar, et al., 2010; WHO, 2010; Zhang & Smith, 2003
Carbon monoxide	Fuel/tobacco combustion, tobacco smoke, cooking appliances	Memory loss and neural dysfunction, hearing deficiency, fatigue, forgetfulness.	Bernstein et al., 2008; Gurjar, et al., 2010; Smith & Mehta, 2000
Polycyclic aromatic hydrocarbons	Fuel/tobacco combustion, fumes from food being cooked, e.g. from cooking oil	Cancer, cataracts, kidney and liver damage.	Bernstein et al., 2008; Lisouza, et al., 2011
Nitrogen oxides	Fuel combustion	Irritations to skin eyes and throat, asthmatic reactions.	Gurjar, et al., 2010; Sakai et al., 2004
Benzene	Building materials, furniture, carpets, cooking systems, stored solvents, environmental tobacco	Cancer, excitation, headaches, nausea and dizziness, fatigue.	Gurjar, et al., 2010; Sinha et al., 2006
Volatile and semi-volatile organic compounds	Fuel/tobacco combustion, consumer products, furnishings, construction materials, fumes from food being cooked, e.g. from cooking oil	Allergy, immune system dysfunction, respiratory system dysfunction.	Adgate et al., 2004; Bernstein et al., 2008; Gurjar, et al., 2010; Sakai et al., 2004
Formaldehydes	Furnishing, construction materials, cooking appliances	Cancer, respiratory effects, irritation to the eye, asthma and allergies.	Gurjar, et al., 2010; Sakai et al., 2004; Zhang & Smith, 2003
Pesticides	Indoor pesticides and insecticides	Skin diseases.	WHO, 2010; Smith & Mehta, 2000
Trichloroethylene	Cooking appliances and washing machines	Cancer, immune system dysfunction, neurotoxic effects.	National Academy of Sciences, 2006; WHO, 2010
Radon	Soil under building, construction materials	Lung cancer.	Lin et al., 2007; Zhang & Smith, 2003
Environmental smoke	Smoking	Tuberculosis.	Eze et al., 2014; Lin et al., 2007

The general techniques that can be used to control, reduce or eliminate the indoor air pollutants including particulate matter removal or substitution at source, ventilation or dilution, isolation, filtration and purification, and education and training of building occupants (Table 2). These techniques can be considered from the design, construction and operation of the buildings.

Table 2: General techniques that can be used to reduce indoor air pollution

	Technique	Description	Technique best for
1	Removal or substitution at source	• Involves removing or modifying the source of pollution and replacing it with a low-pollution substitute (Liu & Liptak, 1999).	All pollutants.
2	Ventilation or dilution	• Fan to blow out the pollutants while window near stove is open (Liu & Liptak, 1999) • Installation of chimneys in kitchens and provision of adequate windows in terms of size and number • Properly location of windows to create effective airflow	Carbon Monoxide and Suspended Particulate Matter.
3	Isolation	• Isolating certain sources of pollution and preventing their emissions from entering the indoor environment • Removing particles using Filters made of charcoal, glass fibers, and synthetic materials • Putting vapor barriers to prevent Formaldehyde outgassing and other volatile compounds from urea–formaldehyde foam insulation, low-permeability paint applied to interior walls; and plywood coated with shellac, varnish, polymeric coatings	Volatile organic compounds.
4	Filtration and Purification	• Removing particles using Filters made of charcoal, glass fibers, and synthetic • Removing particles larger than 0.3µm, which include bacteria and spores, but not viruses using High-efficiency particulate air (HEPA) filters • Use of adsorbents such as activated charcoal, activated alumina, and silica gel to adsorb the particles • Photolcalytic oxidation (Wang *et al.*, 2007).	Formaldehyde and Ammonia.
5	Education and training of building occupants	• Conducting mass education campaigns • Combined effort to implement regular trainings at all levels.	All pollutants.

Indoor air pollution global trends

Indoor air pollution is an important cause of morbidity and mortality throughout the world and has been identified as one of the major contributors to diseases and many other health problems (Gurjar, et al., 2010; Mestl & Edwards, 2011). Higher levels of indoor pollutants have been reported in countries such as Norway, United States, Turkey and Korea (Colbeck & Nasir, 2010; Son et al., 2003). Therefore the health problems arising from higher indoor pollutant levels need to be underscored as they are apparent (Institute of Environmental Health and Engineering, 2003). It has been reported that about 36% of the global acute lower respiratory infections, 22% of the chronic obstructive pulmonary diseases and 1.5% of global cancer diseases are attributed by indoor air pollution (WHO, 2002). Furthermore problems related to indoor air pollution have been reported in similar studies in New Guinea (Bruce *et al.*, 2000), South Africa (Oguntoke, et al., 2010), Brazil (Bruce, et al., 2000), China (Bruce *et al.*, 2002), Guatemala (Bruce, et al., 2002) to mention a few. However the pollution levels have been reported to be higher in rural areas affecting mostly the poor families (Institute of Environmental Health and Engineering, 2003).

The most significant source of indoor air pollution is the biomass use which has attributed to release of a number of pollutants (Qian *et al.*, 2007). It is estimated that indoor air pollution from biomass burning is responsible for 4% of the global burden of disease (Bruce, et al., 2000), and a conservative estimate indicates that the practice of biomass fuel

use endangers the health of 400–700 million people across the globe and causes 2.8 million premature deaths every year (Bruce, et al., 2000). The severity of indoor air pollution is much more in rural households of the developing countries due to burning of traditional biomass fuels such as wood, animal dung, and crop residues for daily domestic cooking (Gurjar, et al., 2010). Smoke emitted during biomass burning contains a wide range of pollutants including particulates, carbon monoxide (CO), oxides of nitrogen and sulfur, polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and trace metals including Fe, Cu, Ni, Cr, and Pb (Bruce, et al., 2000). Airborne particles with a diameter of less than 10 μm (PM) are hazardous because they can be inhaled deep inside the lungs and thus serve as a vehicle for toxic matters that usually adsorb onto their surface (Gurjar, et al., 2010). Studies show that about 85% of the global particulate exposure occurs in indoor environment and out of this 77% is attributed by developing countries only (Institute of Environmental Health and Engineering, 2003). This justifies the fact that indoor air pollution is mostly significant in developing countries. Studies on indoor air pollution in developing countries indicates that approximately 90% of the rural households depend on biomass from wood, dung and crop residues as a source of energy for cooking and they are usually burnt indoor (Bruce, et al., 2000). On the other hand solid fuel use from biomass has been ranked as the third highest risk factor in developing countries (Smith & Mehta, 2000). Literature reveals that people in developing countries are averagely subjected to high pollutant levels for 3-7 hours every day (Bruce, et al., 2000) and that women and children who spend substantial many hours on biomass smoke as they are carried by their mothers are at higher risk (Larson & Rosen, 2002). Diseases arising from indoor pollution reported in developing countries include respiratory infections (Bruce, et al., 2000), low birth weight (WHO, 2010), chronic bronchitis (Bruce, et al., 2000), emphysema (WHO, 2010) and lung diseases (Yu & Crump, 2010).

Indoor air Pollution in Tanzania

Scale and Magnitude of Indoor air pollution in Tanzania

More than 80% of the population in Tanzania lives in rural areas and about 94% of the energy needs for cooking purposes is usually met through biomass particularly burning wood, animal dung and crop residues (SNV, 2013). According to the energy policy of Tanzania biomass energy is used by more than 95% of the population (United Republic of Tanzania, 2003). The source of energy is characterized by possibility for release of air pollutants that can injure the health of the users. This suggests that most of these people are also exposed to the effects associated with biomass use. Although the problem seem to be significant but the assessment of indoor air pollution from the combustion of wood in Tanzania has rarely been reported and the levels of pollutants are not well established (Jackson, 2009).

However from the few studies done by Jackson, 2009, Kilabuko et al, 2007, Oguntoke et al, 2010, it is possible to describe the magnitude and scale of the problem in Tanzania. One of the areas that have been researched includes the exposure time to indoor pollutants. The time spent by people while cooking can determine the exposure time. The more the cooking takes time the more the pollutants continue to be emitted and inhaled. The concentration of such pollutants may decrease with time and ventilation rate in the indoor environment after the cooking has stopped. A study conducted by Jackson in 2009 in the Coast region of Tanzania indicate that the cooking time ranges from 45 minutes to 3 hours per meal and that cooking is done three times a day (Jackson, 2009). This means that most of the rural residents utilize a significant time in cooking, and are exposed to the pollutants released during cooking as such pollutants do remain in indoor environment after cooking stops. Kilabuko et al (2007) reported that in some cases the cooking facilities are located in living room. This exposes people not involved in the cooking to the released pollutants. Therefore, there is direct exposure to the pollutants emitted from cooking due to less efficient cooking facilities and poor ventilation. In such situation the common reported gaseous, liquid and solid substances such as suspended particulates, carbon monoxide, hydrocarbons, nitrogen oxides, sulphur oxides, ozone and lead are emitted into the environment (Oguntoke, et al., 2010).

Despite this situation, few studies have been done to determine the levels of pollutants in the indoor environment. Some of the pollutants whose levels have been established include particulate matter,

carbon monoxide and sulphur dioxide. In one study conducted it was revealed that the particulate matter PM_{10} concentrations were significant in indoor environment as compared to the outdoor environment. Also the PM_{10} concentration was higher during cooking than off cooking (Kilabuko et al., 2007). These results indicate that cooking generates high amounts of particulate matter. Again levels of carbon monoxide (CO) have also been found to be significant in the indoor environment especially where cooking is done. Jackson (2009) revealed that the average hourly CO concentration during cooking with the fuel wood was 325 ±211 mg/m^3 which is much higher than the WHO hourly standard of 30 mg/m^3. It was also established that the average sulphur dioxide concentrations measured during cooking were 14.7±2.3 µg/m^3 and the hourly average suspended particulate matter concentration during cooking ranged from 13,571 µg/m^3 to 305,798 µg/m^3 (Jackson, 2009). All these results suggest that the impact of indoor air pollution is significant and that more research is needed to alleviate the problem.

The indoor environment is also polluted from tobacco smoking. Studies indicate that tobacco smoking prevalence in Dar es Salaam is 27% in males and 5% in females (Green, 2007; Jagoe *et al.*, 2002; Mori *et al.*, 2013). Although the prevalence seem to be not significant but the effect of exposure to second hand smoke both in urban and the rural areas may be significant provided that smoking is done in undesignated environments especially the poorly ventilated rooms. The victims for second hand smoke are usually the women and children who receive the smoke from the smoking husband or father. In urban areas practices such as carpeting do increase the possibility for indoor air pollution. Carpeting can trap microorganisms firmly and promote their survival and dissemination (Gurjar, et al., 2010). Therefore most of the people in urban areas such as Dar es Salaam and Arusha are also exposed to indoor air pollutants arising from the use of carpets.

Causes of Indoor air pollution in Tanzania

The major cause of indoor air pollution in Tanzania is biomass combustion especially during cooking. Environmental tobacco smoking poses another source of indoor pollution where as the toxic chemicals as pointed above are released into the environment (Jagoe, et al., 2002). Paints and other construction materials do pollute the indoor environment especially in urban and peri urban areas where the paints and sophisticated buildings materials are used. Household aerosols or pesticides do release some pollutants to the indoor environment as they are applied to kill some insects. Application of insecticides to kill mosquitoes being common in Tanzania makes it another important source of indoor air pollution (Hanson et al., 2009). Construction materials and household products play a role in indoor air pollution in urban areas of Tanzania. However, pollution from radioactive materials such as radon may also be applicable to both urban and rural areas as it originates from natural materials used in construction activities

Risky behavior/practices attributing to indoor air pollution in Tanzania

From the available information, it has been noted that some of the indoor pollutants can be reduced with increased public awareness and changed behavior. The awareness can help in eliminating those negative behavior hence promote the wellbeing of the people. Some of the behaviors that are notable in various areas of Tanzania are described in sections 3.3.1-3.35. However, it must be noted that while all these behavior are true the main root cause of these may be poverty as well. This suggests that, the best solution to the problem needs a combination of both economic empowerment and raising awareness.

Use of wood and charcoal stoves for cooking in poor ventilated rooms

Most of the population of the Tanzanian use either charcoal or firewood for cooking purposes. The use of unimproved charcoal cooking stoves and firewood in closed poorly ventilated environment makes a higher possibility for partial combustion resulting into release of air pollutants that when inhaled, can cause various health problems. This practice has been associated with the prevalence of breast cancer risk from PAHs (White *et al.*, 2014) as well as irritation and respiratory problems arising from smoke (To & Yeung, 2011).

Burning of plastic to light on the stoves

It has been observed that some people use plastic bags for lighting the cooking stoves. This is mainly done in urban areas where the availability of biomass is limited as compared to the availability of used plastic bags. But the practice is environmentally unsound as burning of plastics produces harmful byproducts such as PAHs (Simoneit *et al.*, 2005). The exposure to the pollutant and the associated effect is even higher when the burning is done indoor.

Use of unimproved stoves and firewood for room heating

In areas with very low temperature or in seasons of low temperature some people tend to heat the rooms using charcoal stove. This practice is of risk especially when it is done in closed indoor environment as eventually oxygen can be used up and partial combustion may possibly happen and produce toxic gases such as carbon monoxide.

Occupying unfinished houses or rooms

Due to economic constraints and the higher renting charges, a significant number of people in Tanzania occupy houses before they are finished and continue with the development slowly as funds are available (Magigi & Majani, 2006). In this situation, the construction activities especially the finishes happen while people are living in the house. Activities such as painting and applying vanish expose the occupants to chemicals and particulate matter that can eventually affect their health. These practices coupled with lack of awareness on the possible effects that can be encountered, hinders the possibility for taking precautionary measures against the release of pollutants.

Smoking in indoor environment

Environmental smoking is one of the sources for indoor pollution (Zhang *et al.*, 2013). Most of the people who smoke are not aware on how they adversely affect the people who inhale second hand smoke. Women and children who sleep in a room with a smoking husband or father are exposed to ETC and are likely to be affected in the same manner.

Suggested sustainable solutions to indoor air pollution problems in Tanzania

Biogas

A shift to alternative better and modern energy sources is of paramount for Tanzania and the world in general (Kanagawa & Nakata, 2007). Biomass is condemned of environmental degradation but also of the pronounced health effects arising from indoor pollution. The use of waste to generate biogas is one of the areas that need to be emphasized. The technology has proved to work better in countries such as Thailand (Limmeechokchai & Chawana, 2007), Rwanda (Landi *et al.*, 2013), India (Lohan *et al.*, 2015), Bangladesh (Khan *et al.*, 2014) and has been recommended for developing countries when the challenges for its adoption are addressed (Surendra *et al.*, 2014). This option serves in providing clean and friendly energy but also in utilizing the waste that would have caused to incur some costs for their disposal.

Improved housing conditions

Housing condition is one of the major elements for indoor pollution. Studies indicate that housing conditions have significant contribution on the exposure to indoor (Colbeck & Nasir, 2010; Smith, et al., 2004). For instance, houses with proper ventilation are reported to significantly reduce indoor air pollutants. Thus, improvement of the housing conditions is one of the strategies to minimize the problems related to indoor air pollution (Bernstein, et al., 2008; Yu & Crump, 2011). Unfortunately the housing sector in Tanzania is coupled with a number of challenges including uncontrolled housing construction. The problem is even more significant in rural areas where the construction is affected by both poverty and lack of awareness. The issue at hand is that very few houses follow the prescribed construction procedures and standards as a result most of the houses are substandard. It has been reported that many houses are constructed of poor materials and do not have the required amenities (United Republic of Tanzania, 2015).

Raised awareness of the people

It has been observed in many areas that even where the housing condition is good improper practices such as burning of plastics in indoor environment still do exists. Awareness has proved to be the most effective in addressing the behavioral practices therefore such practices cannot be eliminated except through awareness programs (Rao *et al.*, 2005). In Tanzania for example some of the reported risky behaviors do exist because of lack of awareness and knowledge. This observation can be anticipated for the rest of the developing countries.

Improved cooking facilities

Because the proportion of people using biomass as a source of energy for cooking is large, efforts have been made to improve the cooking stoves. Through this the biomass consumption is reduced and the generation of the air pollutants is also reduced. It has been reported that through the use of improved cooking stoves, the amount of charcoal and time used for cooking has been reduced by 50% (Pesambili, et al., 2003). Though the use of charcoal for cooking is not environmentally friendly but the shit to alternative energy cannot be an overnight task because of the relatively higher costs for the available alternatives and lack of awareness among the community members. Therefore, adoption of improved stoves can serve in the transition period to use of alternative environmentally friendly energy sources.

Areas for further research in Tanzania

It seems that biological pollutants are one of the significant pollutants of the indoor air that can arise from normal indoor activities. But few studies have been done on this area especially on establishing the sources, levels and associated health impacts in Tanzania. This area needs to be well researched for generating knowledge for informing decision makers and the public in general.

Radon can originate from natural materials and construction materials such as concrete and can be emitted into the indoor environment. In Tanzania, Uranium has been discovered in several parts such as Namtumbo in the South of Tanzania (Mohammed & Mazunga, 2013). This suggests that the soil, rocks and construction materials used in construction may be radioactive and can emit radon. Studies are needed to establish levels of radon in the indoor environment as most of the studies undertaken have not tackled this problem. Establishment of the extent and impacts as well as the number of people who suffer from effects associated with biomass use as source of energy in general need to be done.

CONCLUSION

The indoor air related public health problems are evident and prevalent. Therefore, indoor air pollution studies need to be emphasized among researchers. With the fact that not much has been done in terms of research in developing countries where most people are affected, more efforts on research should be done. While this is true, it must be noted that inappropriate sources of cooking energy and risk behaviors among the community members have evolved to be the main issues. It therefore follows that, strategies for improvement of the existing conditions should target the aspects of source elimination, living condition improvement and public awareness. The later aspect ensures that people have the motive to take actions against the indoor air related problems.

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