NATURAL VENTILATION, DAMPNESS AND MOULDINESS IN DWELLINGS IN THE WATERLOO HOUSING DEVELOPMENT (DURBAN METROPOLITAN AREA):

A CASE STUDY OF INDOOR AIR QUALITY

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ABSTRACT

Dampness can cause the development of moulds in buildings and pose a threat to the quality of the building structure, indoor air quality and health of the occupants. An emerging source of housing related problems are the building materials commonly used in housing construction, which can influence respiratory health. There is concern regarding the quality of the housing stock in the Durban Metropolitan area with regard to dampness and its the potential impact on the health of occupants. To elucidate this issue, a study was conducted to assess natural ventilation, dampness and mouldiness in dwellings of the Waterloo Housing development (Durban Metropolitan Area), between February 2001 and December 2003.

A total of 491 randomly selected homes were visually inspected and residents were surveyed by means of a structured questionnaire. Three hundred and eighteen (318) air and surface mould samples were collected in duplicate, totalling 636 samples and analysed in the laboratory. Building characteristics and physical conditions were recorded and noted. Temperature and relative humidity readings were also taken during the survey. After the analysis of the 491 questionnaires, physical conditions of the dwellings were found to be poor and of concern. With the number (1178) and size of habitable rooms in the dwellings; the occupancy of 2414 people with an average of 2.05 persons per room, indicated overcrowding and congestion. About 51% (n=249) of the dwellings surveyed were found to be experiencing dampness (>$3m^2$) and 47% (n=230) had visible surface moulds, primarily on the walls (at least an average of $1m^2$). Predominant airborne fungal organism identified included; *Aspergillus* (23%-indoors, 26-outdoors), *Cladosporium* (47%- indoors, 51%-outdoors), *Penicillum* (27%-indoors, 26%-outdoors) spp. Natural ventilation was also inadequate in 261 (53%) dwellings, which did not have airbricks. This inadequacy significantly promotes the occurrence of dampness and surface moulds ($p < 0.05$). With poor ventilation, dampness and mould growth in the dwellings, there was a high number of cases with upper respiratory tract health complaints; like Cough – 25% (n=122), Sinuses – 25% (n=121), flu symptoms – 23% (n=110) lower respiratory infections such as asthma – 27% (n=130), and chest infections – 23% (n=113). Asthma, wheeze, runny nose and allergy to dust were statistically associated with dampness ($p < 0.05$), mouldiness ($p < 0.03$) and lack of ventilation ($p < 0.01$).

Buildings separate their occupants from hostile external environments and create a better internal environment for them, therefore dwellings must be constructed in a manner that promotes the health and well being of the occupants. In terms of guiding regulations, there were several omissions and non-compliance with existing local building bye-laws in the construction of houses, leading to adverse implications. Improved workmanship, appropriate material selection and compliance with the relevant guidelines during planning and construction *inter alia*, are recommended when addressing housing issues, thereby promoting the interest, health and well-being of the users.

AUTHORS' DECLARATION

The experimental work presented in this thesis represents the original work by the author and has not been submitted in any form to any other University. Where use was made of the work of others, it is duly acknowledged in the text.

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LIST OF ABBREVIATIONS

EPA	Environmental protection Agency
%ERH	Percent Equilibrium Relative humidity
χ^2	Chi square
a_w	Water Activity
B.M.P	Best practical means
BRE	Building Research Establishment
CMHC	Canada Mortgage Housing Corporation
CDHS	California Department of Health Service
Cfu	Colony forming units
DG18%	Dichloran-18%-glycerol
DBH	Dampness in Buildings and Health
HHI	Healthy Home initiative
HVAC	Heating, Ventilation Air Conditioning
IAQ	Indoor Air Quality
MEA	Malt Extract Agar
NAAQS	National Ambient Air Quality Standards.
NHLBI	National Heart, Lung and Blood Institute
NBR	National Building Regulation
^{o}C	Degrees Celsius
SBS	Sick Building Syndrome
SDBD	Scottish Development Building Directorate
v/v	Volume per volume
VOC	Volatile Organic Compounds
SVOC	Semi Volatile Organic Compounds
w/v	Weight per volume
WHO	World Health Organisation

CHAPTER 1

GENERAL BACKGROUND AND AIMS OF THE STUDY

1.1 BACKGROUND OF THE STUDY

Inadequate housing can be considered a multi-factorial epidemic – rapid urbanization, economic restructuring, natural disasters and political events such as regime changes all have contributed to this crisis (Brown, 2003). In China, where the economy is modernizing rapidly, increasing urbanization in the next few decades will create a need for more than 200 million new housing units, almost twice the total number of existing housing units in the United States (Spengler, 2003).

Housing affects health in many different ways (Brown, 2003). In a study of 9-11 year old children in 24 North American countries, it was found that chronic respiratory symptoms (bronchitis, asthma and lower respiratory) were significantly associated with reported home dampness and presence of mould (Spengler *et al.*, 1994). In a cross-sectional study of pre-school children in Finland, Jaakkola *et al.,* (1993) found that persistent coughing, wheezing, phlegm and nose symptoms were positively associated with the presence of moisture and visible moulds. In a cohort study of 8-12 year old children in six U.S cities, Brunekreef *et al.* (1989) concluded that there was a consistent and strong association between reported dampness in the home and childhood respiratory symptoms. A number of studies have shown a relationship between acute lower respiratory infections (ALRI's) and indoor air pollution arising from the use of wood, coal and paraffin in South Africa.

In South Africa, estimates indicate that infant mortality rates due to (ALRI's) are, at a minimum, 7 times greater than those recorded in western European countries (Von Schirnding *et al.,* 1991). Similarly, the Vaal Triangle Air pollution health study found that the use of coal for cooking and heating was the most significant risk factor for the development of respiratory illnesses in children (Terblanche, 1998). Thomas *et al.,*

(1999) showed that residents of Port Elizabeth experienced problems in household environments that included mould and dampness, thermal inefficiency, overcrowding and the siteing of shacks in poor locations. Other problems were related to poor natural ventilation and use of paraffin (kerosene), the main cooking fuel used by the less wealthy communities. In a study carried out in Austerville and Merewent suburbs situated south of Durban by Sekhotha *et al.* (2000), where a total of 150 homes were sampled, 42% of the residential buildings had indoor-surface mould problem. This percentage was higher than the study of Gqaleni *et al.*, (1999) who found that about 32% of residential homes in another area of Durban were mouldy.

Deficient housing, planning and provision can compromise the most basic needs of water, sanitation and food security allowing the rapid spread of communicable and food-borne diseases. Other problems, such as inadequate temperature and humidity regulation, can lead to discomfort and respiratory illnesses. High levels of indoor humidity can result from insufficient ventilation in areas that are situated in basements and condensation on surfaces due to temperature differences (Lacey, 1994). Durban is a costal, and therefore a humid city. It is generally warm throughout the year with temperatures reaching peak levels in summer. In such conditions ventilation would play an important role in the control of indoor mould growth (Singh, 1994). Overcrowding brings both physical and psychological dangers. Conditions of overcrowding have fostered physical health problems such as typhoid fever and bronchitis, as well as depression (Brown, 2003). In developing countries, overcrowding and poor ventilation can encourage the growth of disease vectors such as mosquitoes, parasites, bacteria and viruses (Brown, 2003).

Setting Indoor Air Quality legislation in South Africa, poses a great challenge in that there are pertinent questions and difficult issues that needs to be addressed and considered; these include:-

What will the guidelines be based on; Health, comfort, etc ?

Where are the guidelines going to apply; homes, offices, etc ?

Who are the guidelines going to protect ?

Who is going to implement and monitor the policies and guidelines ?

Who are responsible for the compliance on the guidelines ?
What are the legal implications of enforcements and non-compliance ?

Although the above questions are difficult to ponder, in South Africa there is legislation in place; but there are several issues of importance that need to be considered in order to ensure that critical aspects of IAQ are sufficiently addressed and implemented. The process to formulate Indoor Air Quality Legislation in South Africa and the subsequent implementation of such policy would raise intriguing and difficult questions.

The Ethekweni Municipality, together with the National Department of Housing, has a housing strategy for rectifying the imbalances created by the previous apartheid government of South Africa. With Kwa-Zulu Natal and Durban, in particular, having high rainfall and relatively warm weather throughout the year, most of the buildings are affected by dampness and mouldiness due to high outdoor humidity and temperatures. Poor ventilation, dampness and mouldiness are associated with asthma and other negative respiratory health issues. The study was initiated in Waterloo, an area approximately 50 kilometres north of Durban under the jurisdiction of the Ethekweni Municipality, North Operational Entity. The area of Waterloo, has approximately 1500 dwelling units and accommodates about 12 500 people (Figures from the Housing Department, North Operational Entity - 2003). Dwelling units consists of one, two and three rooms. Buildings are made of concrete walls, metal, asbestos or bricktiled roofs. Limited no. of studies have been conducted in areas of low-cost housing and therefore the researcher initiated this study and a strategy to identify problem areas and provide remedial measures for future development, as the housing delivery process is a continuous one. The study was undertaken with the following objectives in mind :-

- To investigate natural ventilation efficiency, dampness and mouldiness in the Waterloo Low-cost Housing Development.
- To conduct a building assessment to identify factors that contribute to the presence of indoor mouldiness with reference to the National Building

regulations and other legislation.

- To ascertain the potential health issues prevalent in the area associated with these housing conditions.
- To make recommendation for remedial measures and for its implementation in future housing developments.

CHAPTER 2

GENERAL LITERATURE REVIEW

2.1 INDOOR AIR QUALITY

Indoor Air Quality refers to the nature or type of biological or chemical concentration in an indoor environment or it refers to the perception of occupants. It also refers to a situation whereby fresh air supply to a building is done by mechanical means and the quality of that air is affected or influenced by: the occupancy requirement, the surrounding outdoor conditions and the operation of the mechanical equipment (Nortier, 2000). Indoor Air Quality (IAQ) is an important determinant of population health and well-being (WHO, 2000).

It is recognised that the airborne environment, both vast and dynamic, is an important medium for the dispersal of a number of agents of infections and contamination. Studies have shown that chronic exposure to toxins produced by indoor moulds, even in small doses, may lead to severe health effects over a long period (Chang-Yeung, 1995; Bjurman & Kristensson, 1992). Inhalation is believed to have a more systemic effect, since it permits the entry and absorption of dissolved substances into the lungs (Seltzer, 1994) and directly into the blood supply. Biological contaminants do occur in varying proportions in every indoor environment while the potential to produce human illness is ever-present and found to be most prevalent amongst children (Seltzer, 1994). Their rapid development and unique physiological processes make children especially vulnerable to toxins and other pollutants (Lubin & Lewis, 1995). Several studies have confirmed a positive correlation between mouldy homes and asthma mobidity (Bjurman & Kristensson, 1992; Mishra *et al.*, 1992).

The type and number of outdoor mould species may change with time, day, weather season and geographical location. As a result the outside environment may affect the internal microclimatic conditions that may prevail inside the house. These changes may have a direct impact on indoor air quality. Most mould spores enter buildings attached to dust particles during natural ventilation. Therefore, this will result in contamination of the indoor environment especially if conditions are favourable for surface mould growth. These conditions include available water and nutrients. Water can be introduced into the buildings in several ways such as; rain, seasonal changes (Onguluna, 1975), poor building design, defects and vandalism of building. Dampness from the ground is a common problem in buildings that have basements and poorly constructed foundations. Also, high levels of indoor humidity can result from insufficient ventilations (Lacey, 1994) in areas that are situated in basements and condensation on surfaces due to temperature differences. In addition, water can be generated inside the building fabric by the different activities of occupants such as: cooking, washing, watering indoor plants, pets, and the mechanisms used by the occupants to warm up the interior environments during cold (Singh, 1994) and rainy seasons.

One of the important reason to promote research devoted to indoor air has been that day to day we are staying for so many hours indoors, and consequently, we breath more indoor air than outdoor air. This means that, at equal concentration levels of an air pollutant in both compartments, exposure (which is defined as the product of concentration and time) is greater indoors than outdoors. If the indoor concentration exceeds the outdoor level, there is no doubt that exposure is greater indoors. Only if the indoor concentration is less than one tenth of the outdoor concentration, should we be concerned about the concentration to exposure of outdoors than indoors (Seifert, 2002). Generally, there is a 3 step approach in addressing problems of environmental pollution:- Identification and quantification, evaluation and control. This triad is also essential for work on indoor pollution.

There is convincing evidence that poor IAQ is damaging people's health (CMHC,2003). The issue is central to all research in IAQ. WHO estimates that 30 - 40% of respiratory diseases are caused by air pollution (Bruce, 1999). This is particularly dramatic in the case of health effects caused by IAQ due to open stoves cooking in many southern countries. Exposure to high indoor smoke levels is associated with pregnancy related problems such as stillbirths and low birth weight. One study in western India found a 50% stillbirth increase in women exposed to indoor smoke during pregnancy. Likewise, a study in Africa found that cooking with wood greatly increase the risk of stillbirth. Considerable amounts of carbon monoxide have been detected in the bloodstream of women cooking with biomass in India and Guatemala.

The control of IAQ is often inadequate in spite of its significant role in determining health status. Tensions and conflicts often occur between individuals suffering from indoor air pollution and those whose actions negatively influence IAQ. Most exposure to indoor air occurs in private homes, where interventions by public regulation is often considered a violation of personal freedom (WHO, 2000). Furthermore, commercial interests have often delayed the implementation of indoor air pollution controls in spite of scientific evidence of the harmful impact of such pollution on health. To a large extent, the inadequate quality of indoor air arises from a poor articulation, appreciation and understanding of the basic principles underlying the policies and actions related to indoor air quality. As a result, the general public is familiar neither with those principles nor with their associated rights. These principles are articulated in the WHO document on the Right to Healthy Indoor Air (WHO, 2000). Three of them are pertinent to this study and will be discussed.

Principle 1 : Human right to health - everyone has the right to breathe healthy indoor air. The severity of symptoms and the duration of any negative health effects are primary criteria for determining the seriousness and importance of various indoor air pollution health impacts. The quality of indoor air not only has a bearing on health, but also on the quality of life. Exposure to pollutants that quantitatively decrease the health, functioning or comfort of occupants is, therefore unacceptable (WHO, 2000).

Principle 5 : Social Justice – The socio-economic status of occupants should have no bearing on their access to healthy indoor air, but health status may determine special needs for some groups. Social justice refers to the equitable distribution of burdens and benefits within society. Unhealthy indoor air is a burden, and healthy indoor air is a benefit. Therefore, there should be social and economic equity in the distribution of healthy indoor air. Various groups experience different exposures to unhealthy indoor air, eg. the economically disadvantaged (more exposure to environmental tobacco smoke, more poor quality combustion devices), women and the elderly (more time spent indoors), and ethnic minorities (lack of information in the appropriate language). The right to quality indoor air is equally essential for people of all nations and at all socio-economic levels.

Principle 9 : Sustainability - Health and environmental concerns cannot be separated, and the provision of healthy indoor air should not compromise global or local ecological integrity, or the rights of future generations. The provision of healthy indoor air is a fundamental aspect of the design, construction, operation, maintenance, replacement/demolition or conservation of sustainable buildings. However, in providing healthy indoor air, the minimization of environmental impacts is also essential for sustainability. Consideration of sustainable development, sustainable living and sustainable health are all relevant to the promotion of healthy indoor air.

The driving social forces are quality of life, environmental health, affordability and sustainability. The man on the street and decision-makers in South Africa are lacking knowledge on building design techniques and energy resources (Sithole *et al.*, 2001). The trade, especially the building industry, needs to integrate the concept of humans and their living structures as part of the global environment, than being distant from it. Remedial interventions and monitoring should be intended to help educate housing administrators about energy efficiency and health buildings in the mass provision of houses to the people of the country.

These days, sustainable development is generally considered as something positive but rather vague, this might be the reason why nobody is really opposed to it. The historical (and etymological) origin of the term varies from language to language. The English term "sustainability" was created in 1970s; the French corresponding expression ('development durable') is also a recent construction (Kohler, 2002). The German term

('Nachhaltigkeit') derives from the traditional notion used in the 19th century timber industry that was marked by shortage (Bächtold, 1998). The term meant "...not to cut more wood annually than the forest could give each year"; i.e. not to take more than nature could give over a longer period. This definition includes four components:

- Long term (the effects had to be assured in the long term)
- Social concern (restriction of individual user rights in favour of the community)
- Economic (use of resources taking into account economic principles)
- Responsibility (towards a larger community and future generations).

Nowadays, different aspects of sustainable development are generally recognised:

- Ecological aspects linked to resource conservation and carrying capacity
- Economic aspects taking into account the long term conservation of natural and man-made capital
- Social aspects taking into account social capital and intergenerational equity
- Cultural aspects taking into account the conservation of cultural diversity

Indoor air quality standards and methods are a central part of sustainable development objectives to protect human health and comfort. Sustainable development frameworks relating to IAQ objectives to vital economic and social needs in large part of the world. Cultural aspects will be in the centre of conflicts between the invasion of a global industry (tourism, entertainment, etc) and the protection of regional and local cultural heritage. These aspects will also constitute a challenge to the indoor air community in dealing with the highly complex issues of odours, scents and fragrances, both natural and artificial.

In recent research as well as in government policies, sustainable frameworks for the built environment are based on multiple protection goals (Enquete Kommission, 1997), as outlined in figure1 below:

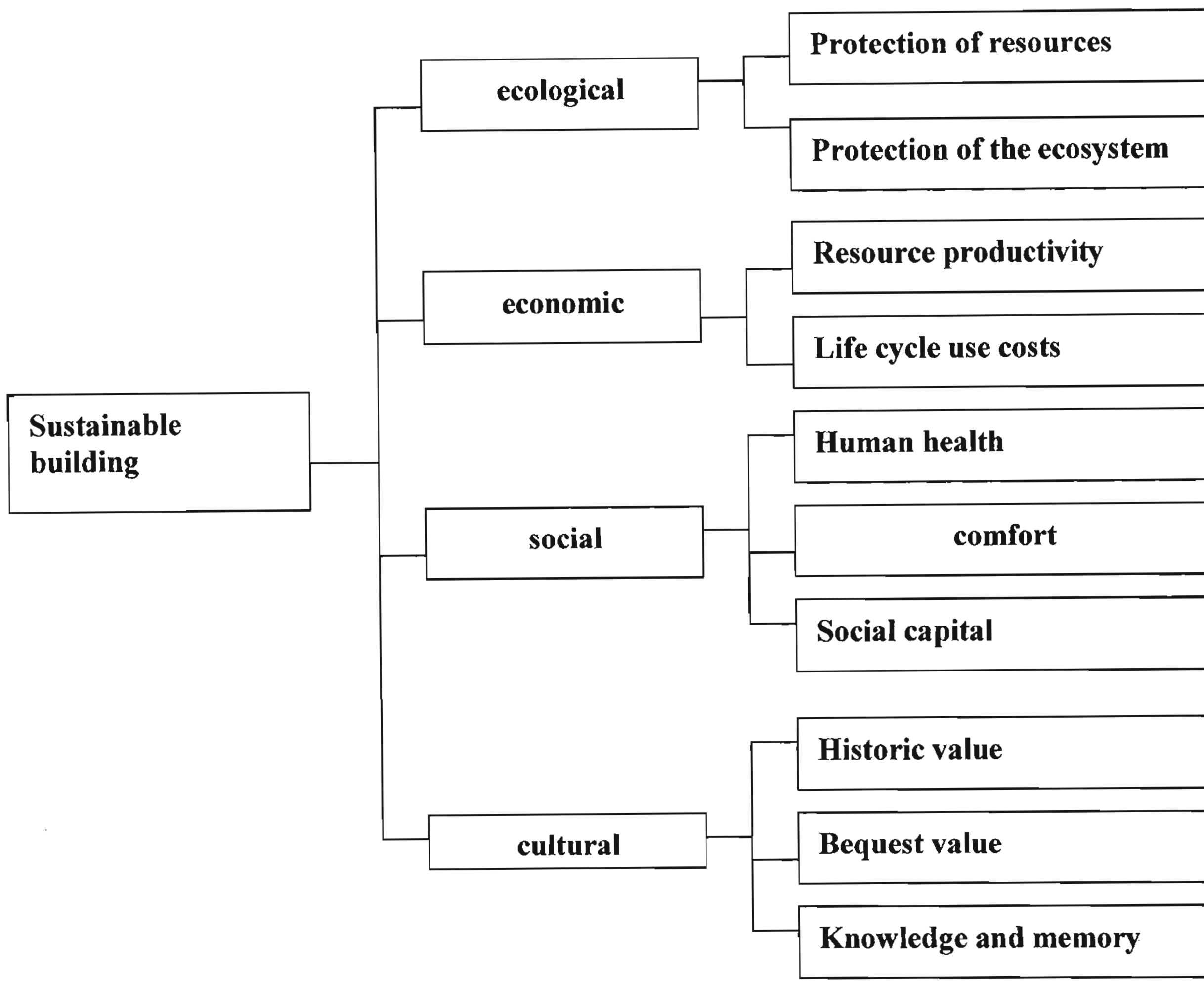


FIGURE 1 : The different dimensions of sustainability and some associated goals for buildings (Kohler, 2002)

Indoor air quality is determined by a large number of different factors including the quality of outdoor air, the type and condition of buildings, the furnishings and the occupants' lifestyle and habits. Consequently, different professions are involved in dealing with and solving indoor air problems. Thus, indoor air sciences represent a truly interdisciplinary field with no separate academic curriculum. This situation is also reflected in the area of legislation. Although there have been calls for legislation that would address the indoor environment in particular, countries generally do not have such specific legislation. Rather, regulations initially intended mainly to serve other areas are also applied to indoor environments, examples, of such regulations are building codes, consumer product safety acts and chemical acts.

The result of this situation is that there is generally no single profession or authority that has full responsibility for IAQ. The same applies at the government level, where a number of ministries are concerned in one way or another with issues related to indoor environment. To avoid the consequence of problems not being addressed adequately because they are shifted from one authority to another, it is suggested that an inter-ministerial task force be established, comprising representatives of those ministries which are most involved. Generally, the task force will then include representatives from the departments responsible for the environment, health, construction, labour, research, industry and transport.

Trade and industry needs to contribute to the achievement of better IAQ. General industry should make as many efforts as possible to reduce hazards resulting from the use of products which have an impact on IAQ (including faulty use and application). The role of the private sector in ensuring acceptable IAQ should be encouraged and supported through education and incentives. Architects, the owners and managers of buildings can impact directly on IAQ if they show due concern for improved design, operation and maintenance of buildings.

Harrison, (2002), questions why there are no standards set and applied to the indoor environment as there are health based standards for the quality of outdoor air. Acknowledging that health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO), which places indoor air quality as one of its contributing factors. The control of indoor air quality is often inadequate in spite of its significant role in determining health (WHO, 2000). The inadequate quality of indoor air arises from the poor articulation, appreciation and understanding of basic principles underlying the policies and actions related to indoor air quality (Molhave, 2002). Awareness of the health significance of good indoor air quality is low in many societies mainly because of insufficient information available to both lay people and policy makers alike. The laws protecting people from harmful exposures indoors are less developed, which potentially increases inequalities in health and aggravates health risks in the less informed, poorer parts of the society and amongst the most vulnerable groups.

On average in Britain people spend 90% of their time indoors and three quarters of that in the home (Smith, 1999). Typically, pollution is lower indoors than outdoors, and the difference is the function of the rapidity of air circulation between outside and inside. There appears to be a linear relationship between particulate concentration indoors and outdoors, with indoor particulates smaller in size. Because most of us spend more that 95% of our lives indoors, in our homes, cars, offices and restaurants (Fourie, 1999), accurate characterization of particle concentration indoors is critical in assessing total exposure to particles. In most cases, concentrations of ambient particles indoors depend primarily upon the quantity of particulate matter that penetrates through the building shell or is transported via heating, ventilation and air conditioning (HVAC) system. In addition, the concentration of particles indoors is affected by several other factors such as filtration, ventilation, deposition, re-emission and indoor sources (Mckone *et al.*, 2002).

Not all indoor pollution is brought in from the outdoors. Household activities, particularly combustion in the kitchen and the furnace, generate pollutants in concentrations that may exceed outdoor pollution. Perhaps the worst indoor pollutant is cigarette smoking, which produces large amounts of CO as well as NO_x and numerous hydrocarbons, including some that are highly carcinogenic (Nauman, 1973). The harmful by-products of smoking are more concentrated indoors than outdoors, increasing exposure to both the smoker and the non-smoker. Several studies have reported an increase number of respiratory symptoms among persons exposed to dampness and microbes in buildings (Brunekreef *et al.*, 1989).

Building dampness may also increase the emission of volatile organic compounds (VOC's) from the materials, eg. dampness in the concrete floor is known to increase the chemical degradation of plasticizers in the polyvinyle Chloride (PVC) floor coating and glues, with the emission of ammonia and VOC's in indoor air (Gustavsson & Lundgren, 1997 and Wiglusz *et al.*, 1998). VOC's can also cause odours in the indoor air. For example, 2-ethyl-1-hexanol has an unpleasant smell and causes irritation of eyes, upper respiratory tract and skin (Wieslander *et al.*, 1999).

Plastic interior materials might be potential sources of chemicals that may cause airway inflammation and also increase the risk of bronchial obstruction and asthma. In a study by Norbäck *et al* (2000), asthma symptoms were more common in 2 buildings with signs of dampness related degradation of di-(ethylhexyl)-phtalate (DEHP) in PVC floor material, detected as presence of 2-ethyl-1-hexanol in indoor air samples. Numerous building materials and furnishings can be colonized and damaged by fungi, especially under humid or wet conditions. Some fungi can produce toxins that can cause negative health effects upon direct contact with the skin, inhalation or ingestion (Burge & Otten, 1999).

In a study by Sekhotha *et al.*, (2000) in suburbs in the Durban South area, 150 homes were randomly selected and visually inspected for dampness and moulds. It was observed that 42% of the homes were mouldy. The main cause of mouldiness in these homes appeared to be poor building design. Most of these homes were poorly ventilated and the roof design was not adequate leading to condensation and subsequent mould growth. It is interesting to note that local hospitals and clinics in Durban are recording an increase in respiratory disease morbidity (Danaviah *et al.*, 2000). This work raises an important question. Could the built environment be a contributing factor?

Another study corroborating the observations of Sekhotha was conducted earlier by Danaviah *et al.*, (2000) in the indoor and outdoor environments of shacks in an informal settlement in Durban. Informal shacks provide almost ideal conditions for the promotion of fungal growth due to high indoor temperatures and relative humidity levels. Most of the shacks lacked proper ventilation and showed signs of dampness and mouldiness. The substandard structure of informal homes created an internal environment which leads to an abundance of mycoflora within these homes. Indoor fungal contamination levels in

60% of the shacks showed high indoor mould levels. The higher colony forming units (c.f.u's) recorded in shacks suggested a possible causal route for the higher incidence of respiratory diseases. Predominant airborne fungal organisms identified included toxigenic and allergenic *Aspergillus* and *Penicillium* species. The unique climate within these homes, primarily due to substandard building design, was considered to be significant in disease causation. Public alarm about indoor mould related problems is placing an increasing burden on Public health officials. These are complex IAQ concerns, and the identification of easy solutions has been complicated by many ill-defined and poorly understood issues; uncertainty regarding the potential harm, widely varying population susceptibility, generally inadequate exposure assessment, undefined regulatory authority and an increasing probability of litigation.

In California, inspection and enforcement of most environmental health issues is the responsibility of local agencies. For matters of indoor air quality, housing and sanitation, the California Department of Health Services (CDHS) is without direct authority. Rather the CDHS Indoor Air Quality Program (IAQP) and the environmental health investigation branch, conducts research, helps develop policies and procedures, and assists local agencies (Waldman, *et al.*, 2002). The US Environmental Protection Agency (EPA) program laboratory for IAQ, the radiation and indoor environment national laboratory, initiated strategic planning to identify IAQ applied research priorities. Three priority research areas were identified as :- bio-contaminants, particulate matter and residential buildings. Their important projects emanating from these priority areas were:- A residential baseline study, sampling and measurement method development, guidelines development and exposure studies. The field of IAQ needs vision and leadership especially from the EPA, the Lead Federal Agency for indoor environments. This leadership should include a residential baseline survey exposure study, guidelines and method development (Angell & Grimsrud, 2002).

Reducing sources of pollutants indoors, plus using effective ventilation are generally workable to achieve good IAQ. Ventilation effectiveness has strong links to IAQ (Zhang *et al.*, 2002). Knowledge transfer and education in this field is a key factor at present in

China. Recently, IAQ issues are receiving more attention from the public and the government than before. But the situation is still not optimistic because the strength is insufficient to cope with the development of China. Two obstacles, IAQ knowledge shortage and public's negligence, exist and block IAQ issues from further improving.
The air pollution prevention Act of the people's Republic of China, which came into effect on September 1, 2000; addresses the prevention of ambient (outdoor) air pollution. In order to control indoor air pollution, the Ministry of Health issued hygienic standards for 12 different categories of public places in 1988, such as, hotels, entertainment halls, bath houses, barbershops, beauty salons, indoor swimming pools, gymnasiums, libraries, museums, art galleries, exhibition galleries, emporiums and department stores, bookstores, hospital waiting rooms, public transportation waiting rooms and restaurants, and issued a revised version of the standard in 1996. There has been no national level, systematic onsite survey from which the situation of indoor air pollution in China could be concluded, neither a comprehensive review of international research and governmental actions, which will be of great benefit to research plan development and IAQ management policy-making and implementation in China.

2.2 VENTILATION

Spores are introduced into the buildings from the outside environment in several ways. One of the common methods is ventilation or infiltration. The type of ventilation used to control interior microclimate conditions may contribute to high colony counts inside the building (Awbi, 1991). These include mechanical, natural ventilation and some housing factors which actively draw outside air which carry spores into the internal environment. If the outside air is not properly filtered or is heavily polluted, it can introduce a large amount of microbial organisms inside the building envelope freely or attached to dust particles.

Methods of allowing natural ventilation inside the building may have both advantages and disadvantages to the occupants as well as the indoor environment. Most buildings with open-able windows, indicate that the interior and exterior environments have the same quality of air and conidia respectively. Poor ventilation efficiency in buildings are not necessary starvation of fresh outdoor air but rather the quality of the air supplied indoors is poor. Problems associated with the poor air quality have been associated with poor maintenance, generation of pollutants indoors and the low outdoor air supply rates. The methods of heating the indoor environment during the winter seasons may also contribute to the humidity levels interiorly.

Ventilation of the home makes a significant difference in terms of problems with dampness, which was very evident in the Port Elizabeth Health study (1999). Eighty percent (80%) of the homes without adequate ventilation experienced dampness, whereas the homes with adequate ventilation measured only 35 % dampness. Natural ventilation is welcomed as long as it does not impose excessive heat gain or heat loss, as the rate of natural ventilation is always higher than that of mechanical ventilation and advantageous instead of removing harmful substances. Even in multi-story buildings, natural ventilation during the night is quite effective in expelling the heat by internal heat generation from lights and miscellaneous office machines. In such a way chemical substances can be removed together. Mechanical ventilation systems on the other hand is effective in introducing a minimum and required amount of outdoor air into indoor space. But mould might develop in the inside of the duct surface and dust accumulates to the extent that duct cleaning becomes necessary (Ishikawa, *et al.*, 1996).

Ventilation rates have an important role on the efficiency of buildings and in respect of good indoor air quality and climate. Residential buildings use between 39 % (Orme, 1998) and 42 % (COM 226, 2001) of primary energy. Its breakdown by end use in the residential sector of EU countries is: space heating, 57 %; water heating, 25 %; cooking, 7 % and electrical appliances, 11 %. Seppänen *et al.*, (1999), reviewed the ventilation rates and human responses with four studies conducted in a jail, barrack, a home for the elderly and offices; and all of them reported significant association between low ventilation rates and the increase in health problems: - pneumonia, upper respiratory illness, influenza and short term sick leave respectively.

The effectiveness of ventilation on productivity was demonstrated by Wargocki *et al.*, (2000), in a simulated office environment. Five groups of 6 female subjects were exposed to 3 ventilation rates (3, 10 and 30 L/s per person). This exercise showed that for each 2 fold increase in ventilation rates, performance improved on an average by 1,7%. The study also indicated that the benefits of ventilation rates well above the minimum levels prescribed in existing standards and guidelines. Any sign of fungal growth in the built environment indicates the presence of moisture and gives warning that some form of ventilation may be required. Natural ventilation provides the easiest form of air movement throughout the building fabric and is one of the best ways of avoiding condensation and the development of fungi. It can be provided by airbricks, air ventilators, open windows, roof ventilators, ventilators in the structural floor voids and dry lining systems.

2.3 DAMPNESS

The amount of dampness may critically affect the development of moulds in industrial and residential buildings. High intensity of indoor surface mould growth and level of dampness, may pose a threat to the quality of the building structures, the status of the building, the IAQ and the occupants health (Singh, 1994). Moisture levels in buildings are influenced by a combination of various factors including; the source and movement of moisture, reservoirs and sinks, insulation, ventilation, external conditions, orientation of the building, materials and occupant behaviour (Singh, 1994). There are two causes of moisture problems – leaks and surface condensation. When warm, moist air comes into contact with a surface that is too cold, moisture condenses. The water and frost collecting on the windows is an example. Over time, if the air in the house is too humid, the house structure may be damaged. Controlling humidity in the home is the best step to prevent mould problems.

The damage of building structures allows water leaks from the outside environment to flow within the building. The seepage of water through cracks in the building, poor foundation and through walls may increase dampness that will increase the growth of indoor moulds. These conditions may lead to an increase in indoor airborne spores that will germinate if growing conditions are favourable (Dales *et al.*, 1991; Summerbell *et al.*, 1992 and Garret *et al.*, 1998).

The association between the occurrence of mould growth and dampness in an indoor environment is of particular importance (Brunekreef *et al.*, 1989; Strachan & Sander, 1989). Dampness from the ground is a common problem in buildings that have basements, one to two floors below the ground level because of poorly constructed foundations. These areas tend to have a problem of high level of indoor humidity due to insufficient ventilation (Lacey, 1994).

2.4 MOULD GROWTH IN BUILDINGS

Moulds are microscopic fungi, a group of organisms which include mushrooms and yeasts. Fungi are highly adapted to grow and reproduce rapidly, producing spores and mycelia in the process. Moulds can be useful to people. The drug Penicillin is obtained from a specific type of mould. Some food and beverages are made by the actions of moulds. Moulds are undesirable when they grow where we don't want them, such as in homes. To have a basic understanding of moulds, the following is helpful:-

- Mould can be harmful or helpful, depending on where it grows.
- Moulds need moisture to grow
- Mould does not grow on dry material
- Mould growing inside a house can affect the occupants
- Occupants can learn to recognise moulds.

Moulds can cause: -

- Unsightly stains
- Damage to paint, wood, drywall, ceiling tiles and fabrics
- Damage to personal items

- Allergies, and;
- Illnesses.

(http://www.cmhc-schl.gc.ca Moisture and air : Problems and remedies)

An emerging source of housing-related health problem is building materials commonly used in new housing, which can influence respiratory health. Composite wood panels such as particleboard are vulnerable to moisture damage that can encourage mould growth. When solid wood stays wet for extended periods, many cellulose-digesting moulds will start growing on the surface. Only a few of these will penetrate into the core of the wood, and then very slowly the particleboard and orientated strand boards will provide pathways and food for fungi through the entire thickness of the material.

Moulds can attack buildings ranging from primitive, poorly maintained ones to newly built modern buildings with high humidity levels and poor ventilation systems. Occurrences of high humidity is due to the high level of damp and moist places created by water from indoor activities and its ingression from the outdoors. Sanders and Cornish (1982) stated that the principal cause of mould growth is dampness resulting from condensation, rising dampness, leaks and water penetration. In rooms that are commonly used by occupants, their activities such as: cooking, washing, watering indoor plants and warming up the interior environments during cold and rainy seasons may generate moisture (Singh, 1994). The moisture generated will condense in cold surface areas due to temperature differences between outside and indoor environments thereby increasing dampness. This will create a suitable growing environment for mould growth due to increased available water on surfaces where condensation occurs.

In a study conducted by Garret *et al.*, (1998), visible mould or condensation was associated with large concentration of *Cladosporium* spores. Mould growth is more severe on the inner surface of building walls, where wallpaper often becomes detached due to the dissolution of adhesive and paint flaking (Singh, 1994). Problems of indoor condensation and dampness in homes are common cause of complaint (Sanders and

Cornish, 1982). A survey in Scotland (SDBD, 1984) and England (BRE, 1985) estimate that between one quarter and one third of homes may be affected to some degree with indoor dampness. An investigation conducted in the United States, Europe and Scandinavia indicated that damp housing accounts for over 50 % of all building problems (Reijula, 1996).

A study by Andriessen *et al.,* (1998) in 13 European cities Pisa (Italy) had the highest (36%) incidence of mouldy buildings followed by Amsterdam (Netherlands), 25.6%. The cities with the lowest percentage of mouldy homes was Oslo (Norway), 2.9% and Kuopio (Finland), 8%. The average number of houses studied in each city was approximately 130. A Scotland study carried out in 1991 by Scottish Housing, showed that around 12.3% of houses are affected by growth of moulds on walls and furnishings with inadequate insulation, heating and ventilation cited as the principal causal factors. Indoor moulds are known to cause a wide spectrum of clinical disease (Burge, 1990, Flannigan *et al.*, 1991; Jarvis, 1990 and Tobin *et al.*, 1987). There are many reasons to link respiratory complications and high concentration of outdoor exposure (O'Hollaren *et al.*, 1991) due to a wide variety of pollutants in an outdoor air environment. There is also a close relationship between respiratory problems and indoor environment due to aeroallergens that are present indoors (Dharmage *et al.*, 1999 and Husman, 1996).

2.5 PHYSICAL REQUIREMENTS FOR MOULD GROWTH

Mould has modest demands for growth: a warm, damp environment with an organic food source. If we keep things dry, moulds do not grow. Unfortunately, most houses offer just such an environment – building materials such as wood and drywall fit the bill of fare; temperatures that suit humans also suits mould; and water coming in from the outside, through the floor, walls or roof or from plumbing leaks, which may seep, leak, condense, or otherwise appear in homes. The main requirements for fungal growth in buildings are: a source of infection (spores, etc.), favourable temperatures (0-25°C), nutrients, oxygen and water. Fungal spores are ubiquitous, although number and types differ with time of day, weather or other factors. Fungi differ in their temperature tolerance, some species still grow slowly below 0°C and others tolerating up to 60°C. The nutrient requirements of fungi are satisfied in the built environment by dust and organic deposits and air movement can provide sufficient oxygen.

Water activity (a_w) or % ERH refers to free water in the substrate relative to that of pure water at the same temperature and pressure (Adan & Samson, 1994 and Ayerst, 1969). Fairly high water activity of their substrates is required. Most construction products should at least have water activities comparable to equilibrium with an air humidity of 70-75 RH to be seriously infested with fungi. The construction products may also be wetted by water leaks, flooding, diffusive transport of water or splashes from activities like bathing. At low (70%) water activities growth is slow and develops over months or years. At higher activities significant growth can develop in a few weeks (Nielsen *et al.*, 2000). Water availability in buildings depends on its source and movement, the occurrence of moisture reservoirs, and sinks, heating insulation, ventilation, external conditions, orientation, the building materials and the occupants.

When moisture sources in the homes are small, increased ventilation may reduce indoor humidity and thereby eliminate fungi and mites. However, the strength of the moisture sources is crucial for the ability of ventilation to control the moisture content of indoor air. Problems caused by high relative humidity at cold surfaces are only in some cases controllable by ventilation. Problems caused by direct wetting of materials can not be handled by ventilation. Many ventilation engineers consider increased ventilation to be the best way to reduce the moisture content of the air in apartments. New ventilation systems may therefore be installed in many places. Increased energy consumption is often an unwanted effect of increased ventilation. Other factors such as, user behaviour and moisture generating appliances may, however, have an equally important impact on moisture content.

2.6 INDOOR AIR QUALITY AND HUMAN HEALTH

Indoor air pollution accounts for the deaths of millions of children each year (Smith, 1987). A report published jointly by UNICEP, UNEP and WHO entitled, "children in the new millennium: Environmental impact on health," states that children under 5 are 10 % of the worlds population, but they bear 40 % burden of environmental related diseases (WHO, 2002). Environmental degradation of air, water and food combined accounts for almost a third of the global burden of diseases. Dr Gro Harlen Brundtland, the former Director of the WHO, has effectively linked environment to poverty bringing the message to many around the world including the World Bank. She reports that tobacco is killing 4 million a year and will increase to 10 million a year in 20 to 30 years if not brought under control (Brundtland, 2002).

Asthma is a chronic respiratory disease characterized by sudden attacks of laboured breathing, chest tightness, and coughing. It is a complex multifactorial disease with both genetic and environmental components. A number of studies have suggested that ambient air pollution can trigger asthma attacks (Bjorken 1999; Koren & Utell 1997). In indoor environments, home bioallergens such as dust mites, moulds, cockroach parts, and animal dander (Dales *et al.*, 1991; Lewis *et al.*, 2002; Litonjua *et al.*, 1997; Rosenstreich *et al.*, 1997; Thorn *et al.*, 2001; Togias *et al.*, 1997; Weiss *et al.*, 1993), and household cleaning agents, pesticides, and mosquito coil smoke (Azizi & Hendry 1991; Azizi *et al.*, 1995; Weiss *et al.*, 1993) have been linked to increased risk of developing asthma.

The role of the indoor environment in asthma is of major concern because, (a) the condition of asthma is increasing in prevalence, (b) we spend more than 80% of our lives indoors and (c) a large proportion of children and young adults with asthma are allergic to allergens such as dust mite, animal dander, cockroach and moulds found indoors. In urban communities in developing countries and even more so in American cities, the population is increasing indoors and asthma has become an epidemic disease that disrupts many families and can cause large numbers of hospital admissions (Woolcock & Peak, 1997, Crater *et al.*, 2001). The move indoors has been accompanied by many changes in lifestyle that could have altered the immunopathology or physiology of the lungs including diet, antibiotics use, sedentary lifestyle and the closely related increase in obesity. However, the move indoors has inevitably involved major changes in the air we inhale including effects on protein allergens, bacterial endotoxins, hydrocarbons and gases such as ozone and NO_2. Asthma brings about an increase in airways resistance by a different mechanism to chronic bronchitis or emphysema, namely bronchoconstriction. Asthma is characterized by an active bronchoconstriction; and the airways of an asthmatic may be regarded as hyper-reactive; they are sometimes referred to as 'twitchy' airways. Any one of a number of stimuli such as pollen, house dust, dust mite, spores, animal fur/hair may be trigger factors in asthma. Bronchoconstriction is undoubtedly the mechanism of a simple asthma attack.

2.6.1 DISTINGUISHING BETWEEN ASTHMA, CHRONIC BRONCHITIS AND EMPHYSEMA

These diseases can usually be distinguished clinically with ease, in addition to results of lung function testing. This is of some importance because asthma is treatable and the airways disease potentially reversible, which is not so in emphysema or chronic bronchitis as the airways have been structurally damaged. Hence, it is dangerous to label an asthmatic patient as suffering from chronic bronchitis or emphysema, because the same therapeutic efforts will not be made. The distinction between chronic bronchitis and emphysema is largely academic but it is important to pick out patients who may be suffering from chronic asthma. The following points may help in distinguishing these cases: -

1) A history: - The patient with chronic bronchitis or emphysema usually has a history of the disease for some years; the asthmatic may often give a history on their diagnoses which often begins in childhood, but may develop at any age.

2) Monitory peak expiratory flow rate may help. Although at any one time reversibility may not be present with bronchodilator, variation in peak flow rate may be apparent. Readings taken in the morning, at midday and at night show a considerable diurnal swing (more that 20% variation).

3) Asthma should be suspected when the patient has what appears to be severe emphysema but a normal transfer coefficient. This sometimes indicates severe chronic asthma. Pulmonary emphysema is a chronic disorder characterised by distension of the alveoli and a loss of lung elasticity (Bloom, 1995). Although chronic bronchitis and emphysema are classified as separate disorders, they commonly co-exist. A frequent complication of chronic bronchitis is chest infection as secretions are not expectorated and become infected. Individuals with chronic bronchitis are usually well aware of the further debilitation and lethargy which results from a chest infection and need to be vigilant for the first signs in order to obtain prompt treatment (Williams, 1993).

4) The final and most effective method of diagnosing asthma may be through administration of steroids in low dosage. If this does not produce a significant reversal of the airways obstruction, then in practical terms the patient does not have reversible airways disease.

Increasing prevalence of asthma in both developed and developing countries has been a major public health challenge for more than two decades (Anderson 1997; Platts-Mills & Woodfolk 1997; World Resources Institute 1998). Many studies have associated indoor housing factors with increased prevalence of respiratory symptoms in children as well as adults (U.S. Dept. of Health and Human Services 1986; Samet & Spengler 1991; Bornehag *et al.,* 2001; Smith *et al.,* 2000).

Wheezes are musical sounds generated during inspiration and expiration. The implication of a wheeze is that the airways are narrowed. Wheezes in the chest do not vary in pitch when the inspired gas is changed from air to a mixture of 80% helium and 20% oxygen (a much lesser dense mixture). Probably a wheeze is generated by an airway whose walls are brought close together, so that they are almost in contact. During gas flow, the walls oscillate and the nature of the wheeze depends on the mass and elasticity of the tissues, which are oscillating. Wheezes are described as monophonic when there is a single source on one pitch; more usually, when they originate from several places, they are polyphonic. Wheezes are commonly heard in all the diseases characterized by airway narrowing; particularly chronic bronchitis, emphysema and asthma.

2.6.2 SMOKING

Numerous studies have suggested that exposure to tobacco smoke can increase the risk of developing asthma (Azizi & Hendry 1991; Azizi *et al.*, 1995; Flodin *et al.*, 1995; Martinez *et al.*, 1992; Strachan & Cook 1998; Thorn *et al.*, 2001). According to one estimate, children have about twice the risk of developing asthma if one or both parents smoke (NHLBI 1995). "A custom loathsome to the eye, hateful to the nose, harmful to the brain and dangerous to the lungs." (King James 1). Cigarette smoke is probably the most addictive and dependence producing form of object-specific self-gratification known to man (Russell, 1974). For example, london drug users rated tobacco as their most needed drug, more than heroin, methadone, amphetamine, cannabis, LSD or alcohol (Blumberg *et al.*, 1974).

Smoking always nearly begins in adolescence for psychosocial reasons, including parental smoking, curiosity, smoking among friends, assertion of independence and rebelliousness. Once smoking becomes regular, the pharmacological properties of nicotine play a major part in the persistence of the habit (Russell, 1976), which appears to become advantageous to the smokers mood or life response (Stepney, 1980) yet is potentially lethal.

2.6.3 THE HARM TO SMOKERS

The excess mortality in cigarette smokers dying of lung cancer, cancer of other respiratory sites, chronic bronchitis and emphysema and cancer of the oesophagus can be directly attributed to smoking. It is also evident that cigarettes smoking causes lung cancer, chronic bronchitis, emphysema and heart disease in women (Doll *et al.*, 1980), it showed a significant dose-response relationship between cigarette consumption and lung cancer mortality in the range 0-40 cigarettes per day (Doll & Peto, 1978). In civil servants current cigarette smokers were shown to have a greater risk of coronary heart disease than those not smoking cigarettes irrespective of blood pressure or cholesterol

(Reid *et al.,* 1976). Men who smoke, more than double their chances of bladder cancer (Lancet, 1971), as well as increasing the morphological abnormalities of their sperm (Evans *et al.,* 1981). Memory can also be affected by heavy cigarette smoking (Weeks, 1979). Cigarette smokers who change to cigars, pipes, lower tar or lower nicotine cigarettes are unlikely to reduce risk as it appears that they continue to inhale or even inhale more to compensate. (Cowie *et al.,* 1973; Castleden & Cole, 1973; Russell *et al.,* 1980).

2.6.4 THE HARM TO NON-SMOKERS

Passive smoking is now known to be harmful. Maternal smoking increased the combined mortality in foetal and neonatal life by 28% and reduced birth weight by 170g (Butler *et al.,* 1972), and the same group found physical and mental retardation between the ages of 7 and 11 which could be attributed to maternal smoking during pregnancy (Butler & Goldstein, 1973). Children of parents who smoke at home are shorter than children of non-smokers (Rona *et al.,* 1981). Exposure to tobacco smoke can cause cough and breathlessness in non-smokers with chronic bronchitis and emphysema and can induce attacks of asthma (Royal College of Physicians, 1977).

Tobacco smoke can result from both, side-stream smoke that is smoke that comes from the burning end of a cigar, and from exhaled smoke. The smoke is a complex mixture of over 4700 gaseous compounds and particulates. The National Academy of Sciences concluded that tobacco smoke is a cause of lung cancer and heart disease in both smokers and non-smokers who are exposed to smoke. Young children exposed to smoking at home are more likely to be hospitalised for bronchitis and pneumonia than children in non-smoking homes. Increasingly, states are passing regulations requiring smoke-free publicly owned buildings and separate space for smokers and non-smokers in restaurants. The reduction of exposure to environmental tobacco smoke in the home is entirely voluntary. The physical separation of smokers and non-smokers in a home reduces but does not eliminate the non-smoker's risk. The same is true for ventilation. The only effective way to eliminate the risk of exposure to environmental tobacco smoke in the home is to eliminate smoking in the home.

The dangers of cigarette smoking have been established beyond reasonable doubt. Health professionals, in alliance with other organizations must continue to find better ways to efficiently educate both public and politicians of these dangers. If resistance to fiscal and restrictive measures persists despite such educational efforts, research into how best to overcome this resistance will be necessary, either at parliamentary, congressional or public level. Established methods of persuading people to quit smoking should be used more widely, especially by general practitioners. Improved methods, both for a mass approach and for use on an individual scale needs to be developed. Further exploration of the means by which cigarettes harm humans must continue, not so much with the hope of developing a safer cigarette, but in the expectation that more precise knowledge will convince remaining doubters, and provide better understanding of the pathogenesis of lung and heart disease, thereby leading to better management. Health education needs tot take into account an individuals perceived reason for smoking and also their reasons for wanting to give up (Galvin, 1992). Rowe and Clark (1993), demonstrated the effectiveness of an individualized smoking cessation intervention, in a small study involving patients in a coronary care unit. From a sample of 10 smokers who participated in an individualised intervention, seven (70%) were not smoking one year after their discharge from hospital. While the sample size and the self selection of the sample make it impossible to generalize these findings, they do accord with the view of Galvin (1992) and Dines (1994) about the importance of emphasizing the individuality of smoking.

In many homes in developing countries, a major source of exposure to indoor air pollutants is cooking smoke, when people rely on unprocessed biomass fuels such as wood, crop residues and dung cakes for cooking and space heating. Because cooking stoves are usually used for several hours each day at times when people are present indoors, their exposure effectiveness is high; that is, the percentage of their emissions that reach people's breathing zones is much higher than for outdoor sources (Mishra, 2002).

In South Africa, estimates indicate that infant mortality rates due to respiratory infections are, at a minimum, 7 times greater than those recorded in Western European Countries. As early as 1982, Kossove, found that over 70% of infants less than 13 months of age with severe respiratory tract infections had a history of daily wood smoke exposure from cooking and heating fires. Children living in homes using coal had a 9.3 times higher risk of developing respiratory illness compared to children living in homes using electricity. The findings that the effect of cooking smoke is greater for women than for men is consistent with expectation, because women are more exposed than men to cooking smoke. A larger effect of tobacco smoking in women than in men may reflect greater vulnerability of women because of their compromised respiratory system from cooking smoke, poorer nutritional status, and less access to treatment and care compared to men. A larger negative effect of the availability of a separate kitchen for men than for women is consistent with expectation because availability of a separate kitchen in the household is more likely to reduce cooking smoke exposure in men than in women, who do much of the cooking.

A study by Nriagu *et al.* (1999) in Durban, showed that cigarette smoking, outdoor industrial pollution, use of insecticides and home ownership were strongly associated with the high prevalence of asthma and respiratory symptoms. An initial survey in Durban (Gqaleni *et al.*, 1999) aimed at investigating the correlation between mould bioaerosols and respiratory health showed 20-40% of children reported frequent respiratory tract (RT) symptoms. Almost 60% of the shacks showed signs of dampness and mouldiness.

2.6.5 TUBERCULOSIS

One hundred years after the discovery of the tubercle bacillus, *Mycobacterium tuberculosis* by Robert Koch, and nearly 40 years after the discovery of Streptomycin, the WHO was constrained to comment that "technically advanced countries have achieved spectacular results in the control of tuberculosis over the last 3 decades...."

Unfortunately, in the majority of developing countries, there has been little, if any; improvements in the epidemiological situation. It is estimated that each year about 10 million people still develop tuberculosis, at least 3 million die from the disease, and the risk of developing TB is about 20 – 50 times greater in the developing, than in technically advanced countries (WHO, 1982). Tuberculosis is a disease of poverty, readily taking advantage of those with weakened resistance due to poor nutrition and general health. Social conditions therefore play a large part in determining a persons susceptibility to the disease.

The following points influence the way in which we view tuberculosis: -

1. It was once a widespread and often fatal disease.
2. In spite of chemotherapy and improved living standards, the disease had not been eradicated.
3. It remains a serious and potentially lethal disease, which if diagnosed early, can be successfully treated.

The predisposing factors related to the Tuberculosis disease, are summarized as follows: -

HOUSING CONDITIONS: - contagion occurs by inhalation of droplets containing the tubercle bacillus coughed up by an infected individual. Poor housing results in overcrowding which facilitates this process. An infected individual will usually only infected those who are close regular contacts.

OTHER CONCURRENT DISEASE: - The risk of Tuberculosis is increased in patients already suffering from diabetes, malnutrition, alcoholism and drug dependence.

AGE: - Tuberculosis is commoner in the young and the very old.

RACE: - The pattern of tuberculosis varies in different racial groups. Immigrants who have come from areas of high prevalence may be especially at risk.

REACTIVATION: - People who have been infected and appear to have healed, quiescent tuberculosis lesions but who have had no, or inadequate; chemotherapy, represent a residual 'sump' of potential disease. Sometimes these lesions breakdown and reactivate. The causes of reactivation are related to the predisposing factors listed above, and the development of another disease, which may debilitate the patient or change his immune state, change in socio-economic position or the development of alcoholism.

Four of the most difficult problems in relating air pollution to health are unanswered questions concerning : (1) the existence of thresholds, (2) the total body burden of pollutants, (3) the time versus dosage problem, and (4) synergistic effects of various combinations of pollutants.

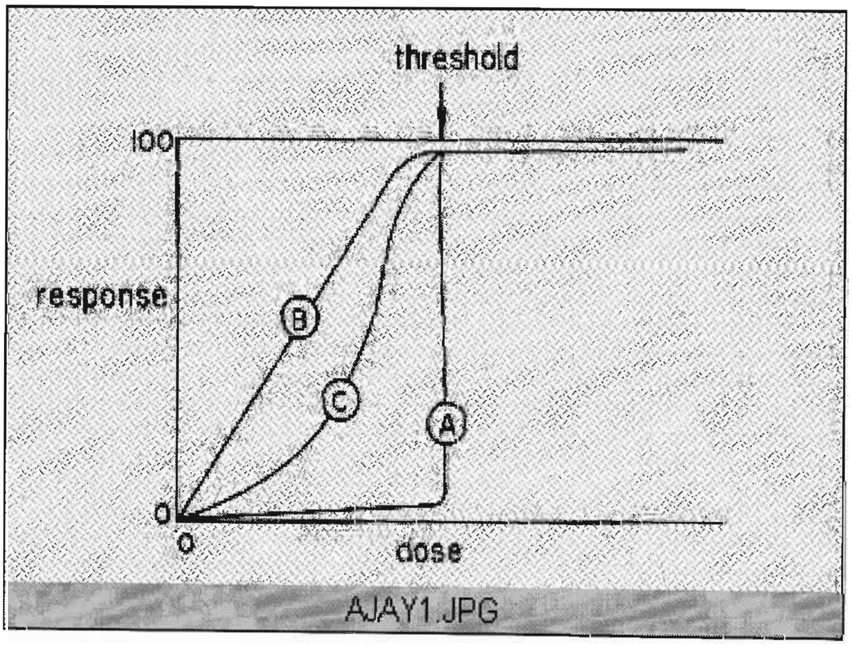
(1) *Threshold* : With reference to Figure 2 there are three basic dose-response curves possible for a dose of a specific pollutant (eg. Carbon monoxide) and the response (eg. Reduction in the bloods oxygen-carrying capacity). Curve A shows that if this dose-response relationship holds, there is no effect on humans metabolism until a critical concentration (the threshold) is reached. Curve B suggests that there is a detectable response for any finite concentration of the pollutant. Curve C seems to be most likely dose-response relationship for many pollutants and suggest no strict threshold, but also shows a minimal response up to a higher concentration, at which point the response becomes severe.

(2) *Total Body Burden :* Not all of our dose of pollutants comes from air. For example, although we breath in about 50 g/day of lead, we take in about 300 g/day of lead in our water and food. In the setting of air quality standards for lead it must therefore be recognized that most of the lead intake is from food and water.

(3) *Time versus Dose* : Most pollutants require time to react, and thus the time of contact is as important as the level. The best example of this is the effect of carbon

monoxide. CO reduces the oxygen-carrying capacity of the blood by combining with the hemoglobin and forming carboxyhemoglobin. At about 60 % carboxyhemoglobin concentration, death results from the lack of oxygen. The effects of CO at sublethal concentration are usually reversible. Because of the time-response problem, ambient air quality standards are set at maximum allowable concentration for a given time.

(4) *Synergism* : Synergism is defined as an effect that is greater than the sum of two or more toxicants. For example, Black lung disease in coal miners occur only when the miner is also a cigarette smoker. Coal mining itself, or cigarette smoking by itself will not cause black lung, but the synergistic action of the two puts miners who smoke at high risk.



<u>FIGURE 2</u>: Possible Dose-Response Curves (Environmental Pollution and Control, 2nd edition, Pg. 254).

The major target of air pollutions is the respiratory system, as illustrated in Figure 3. Air and entrained pollutants enter the body through the throat and nasal cavities and pass to the lungs through the trachea. In the lungs, the air moves through bronchial tubes to the alveoli, the small air sacks in which gas exchange takes place. Pollutants are either absorbed into the blood stream, or moved out of the lungs by tiny hair cells called cilia, which are continually sweeping mucus up into the throat. The respiratory system can be damaged by both particulate and gaseous pollutants. The site and extent of the deposition of particulates in the respiratory tract is a function of certain physical factors, the most important being particle size. Alveolar deposition is especially important since that region of the lungs is not provided with cilia to remove particulates. Thus, particles deposited there would remain for a relatively greater length of time. Other factors that determine the amount of particulate deposition are respiratory frequency (breaths per unit time) and tidal volume (the volume moved in and out of the lungs with each breath).

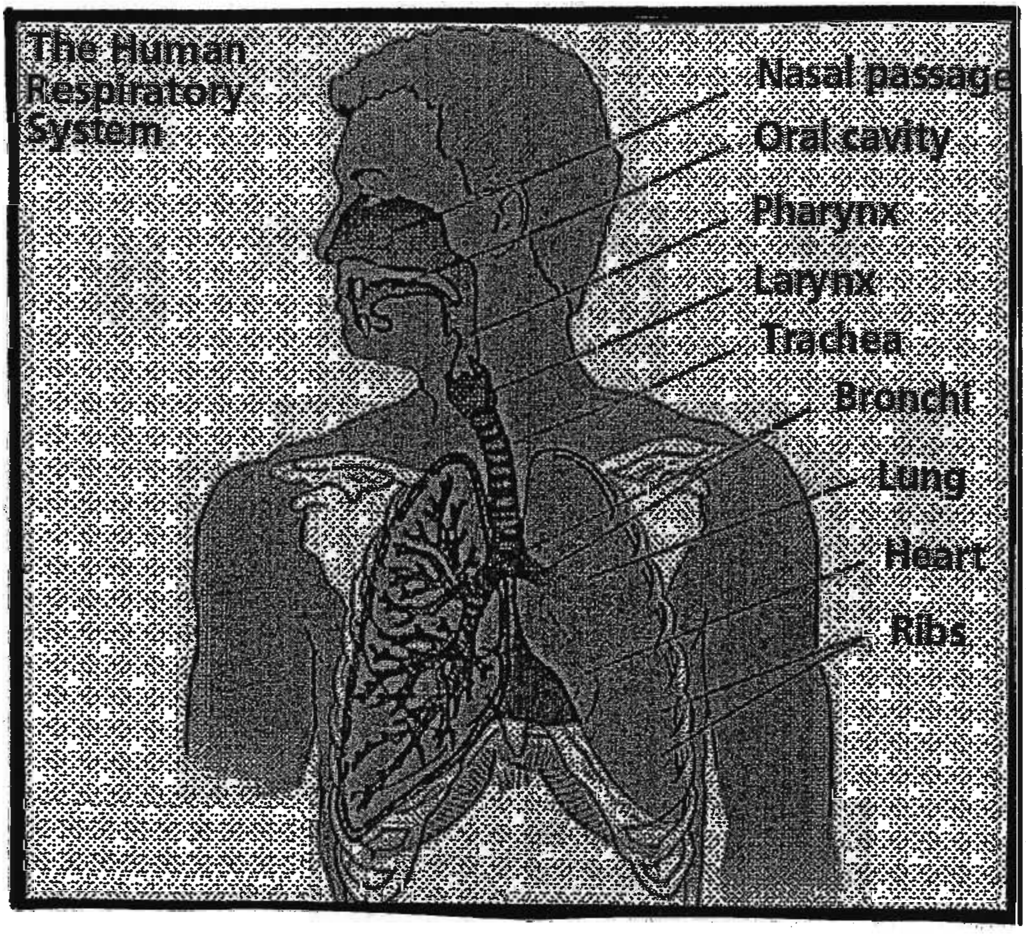


FIGURE 3 : The Human Respiratory System (www.sinauer.com)

Poor IAQ may be caused by a variety of factors including insufficient ventilation, excess temperature, dry air that circulates inside the building, high levels of indoor surface mould growth and volatile organic compounds (VOC) emissions from construction material and furniture (Husman, 1996). Indoor dampness is a potential risk factor for respiratory illness through the action of micro-organisms that thrive in damp environment (Andersen & Korsgaard, 1984). According to the World Health Report 2002, indoor air pollution is estimated to cause 36 % of all lower respiratory infections and 225 of chronic obstructive pulmonary disease in the world. In the United Kingdom, a 1999 report by Diana Wilkinson of the Scottish Office Housing Research Branch titled, Poor Housing and ill health; states; that even though much of the research is fragmented and inconclusive, a strong relationship between defective housing and health is evident. Wilkinson cited several studies showing strong associations between dampness and headaches, sore-throats and respiratory problems including asthma. Radon, dust mites, environmental tobacco smoke, carbon monoxide, and fungal growth were next-highest risks.

The U.S Environmental Protection Agency has rated poor IAQ as being among the top environmental risk to human health (CMHC, 2003). In spite of the fact that American leisure activities tend to be slanted towards outdoor pursuits, some estimates suggest that Americans spend about 80 percent of their time indoors. For most Americans, the risks associated with air pollution may be greater indoors than outdoors. Additionally, the UN Environment programme estimated that the world's population spend and average of 80-90 percent of their time indoors (UN Environment Programme 1988a:81). The most important sources of indoor pollution are radon, tobacco smoke, biological contaminants, combustion products, household products, formaldehyde, pesticides, asbestos and lead. Moreover, the risks increase as a result of the cumulative effects of exposure.

The occurrence of common respiratory infections were studied by Husman *et al*., (2002) with self-reported questionnaires in Finnish schools and the association between respiratory infections and moisture damage in different types of the buildings were estimated. When moisture-damaged, reference school buildings were compared, common colds were significantly more common ($p < 0.01$) in moisture-damaged buildings than non-damaged referenced buildings. Common colds were slightly more frequently found in schools with concrete/brick frame than in school buildings with wooden structure. Moisture damage at home was significantly associated with higher occurrences of common colds, sinusitis and ear infections. Respiratory infections are very common in young age groups. At lease two thirds of school aged children have at least one respiratory infection per year (Husman *et al.*, 2002)

2.7 ANALYSIS OF LEGISLATION AND REGULATION

Historically, Indoor air quality has always been a strong discriminating factor. In (Reid, 1874), a distinction between rich-mans pollution (sopharic rooms caused by candle or gas combustion) and poor mans pollution (humidity and mould growth) is made. Women have suffered particularly from bad indoor air quality, the social and health emancipation of women has traditionally been associated with better housing conditions. This goes from the "American women's house" and the "Octagon house" in the mid 19 th century (Banham, 1969) to the campaigns for better stoves and micro-credit programs in the third world today (World Bank, 2000). For a large part of the world's population in particular women and children, the struggle for better IAQ cannot be separated from the struggle for better survival conditions and sustainable future.

2.7.1 THE SOUTH AFRICAN CONSTITUTION (1996)

In terms of Section 26 of the constitution of the Republic of South Africa, 1996, everyone has the right to have access to adequate housing, and the state must take reasonable legislative and other measures, within its available resources to achieve the progressive realization of this right, and the South African parliament recognizes that :-

- Housing, as adequate shelter, fulfils a basic human need
- Housing, is both a product and a process

- Housing is a product of human endeavour and enterprise
- Housing is a vital part of integrated development planning
- Housing is a key sector of the national economy, and
- Housing is vital to the socio-economic well being of the nation.

2.7.2 THE HEALTH ACT NO. 63 OF 1977

The Act deals with matters pertaining to medical conditions, communicable diseases, and conditions dangerous to health. More emphasis is placed on food, milk and water as conditions risking health, than air which is an equally essential component. There is brief mention on dwellings, and this pertains mainly to its over-crowded and poorly ventilated design as a source of danger to health (Regulation 34).

2.7.3 THE HOUSING ACT NO. 107 OF 1997

This legislation governs the administrative and financial aspects within the housing development and does not emphasize the significance of indoor air quality, which is of prime importance to any habitable structure. Proper ventilation allows for constant air movement and exchange of air which improves the general health of the occupant. In cases where there's poor ventilation, respiratory ailments are common and affect everybody, especially the young and the very old who are more susceptible to such ailments. Pulmonary tuberculosis (TB) is common when people live in congested and overcrowded conditions, where air movement and exchange is limited, and this is even more important at this time, given the resurgence of TB as one of the opportunistic infections of HIV/AIDS.

2.7.4 THE ATMOSPHERIC POLLUTION PREVENTION ACT NO. 45 of 1965

This Act focuses on Air Pollution in the forms of smoke, dust and vehicle emissions. Emphasis is placed on industrial and occupational applications, where particulates are emitted from boiler systems and heating appliances and not in the domestic and residential settings, where particulate matter is also emitted. Despite a person spending almost 80% of the time indoors, the impact on the internal environment by emission source is not focused upon, thereby neglecting its significance. The external environment and its exposure to pollution from sources, such as industries and locomotives, is dealt with.

2.7.5 THE OCCUPATIONAL HEALTH AND SAFETY ACT NO. 85 of 1993

The Occupational Health and Safety Act provides for the health and safety of persons at work, those who use plant and machinery and the protection against hazards. One of the 8 basic rights of the South African employee in the labour field is the Right to protection of their safety and health at the workplace. The South African government in a policy statement in the Manpower 2000 Manifesto acknowledged this.

2.7.6 THE NATIONAL BUILDING REGULATIONS (1985)

Assessing the nine house plans that were drawn and approved by the Ethekwini Municipality and its relevant departments, the requirements of the National Building Regulations and its implementation and adherence were analysed. The plans incorporated the minimum requirements for ventilation and lighting. Having the plans pre-approved and in compliance with the above regulations, one would expect that construction if done accordingly, will further enforce the compliance of the requirements, but this was not the case. Irregularities surfaced during construction and therefore certain inadequacies are encountered, which are discussed in the following chapter.

CHAPTER 3

MATERIALS AND METHODS

3.1 STUDY AREA

Figure 4 indicates the area of Waterloo Housing Development where the study was carried out. Waterloo is situated approximately 40 km north of Durban (Figure 5). The housing development, being a part of the Reconstruction and Development Program commenced 6 years ago and to date has more than 2000 dwellings built and occupied. The area is generally warm with rainfall patterns throughout the year, which leads to ambient air being humid throughout the year.

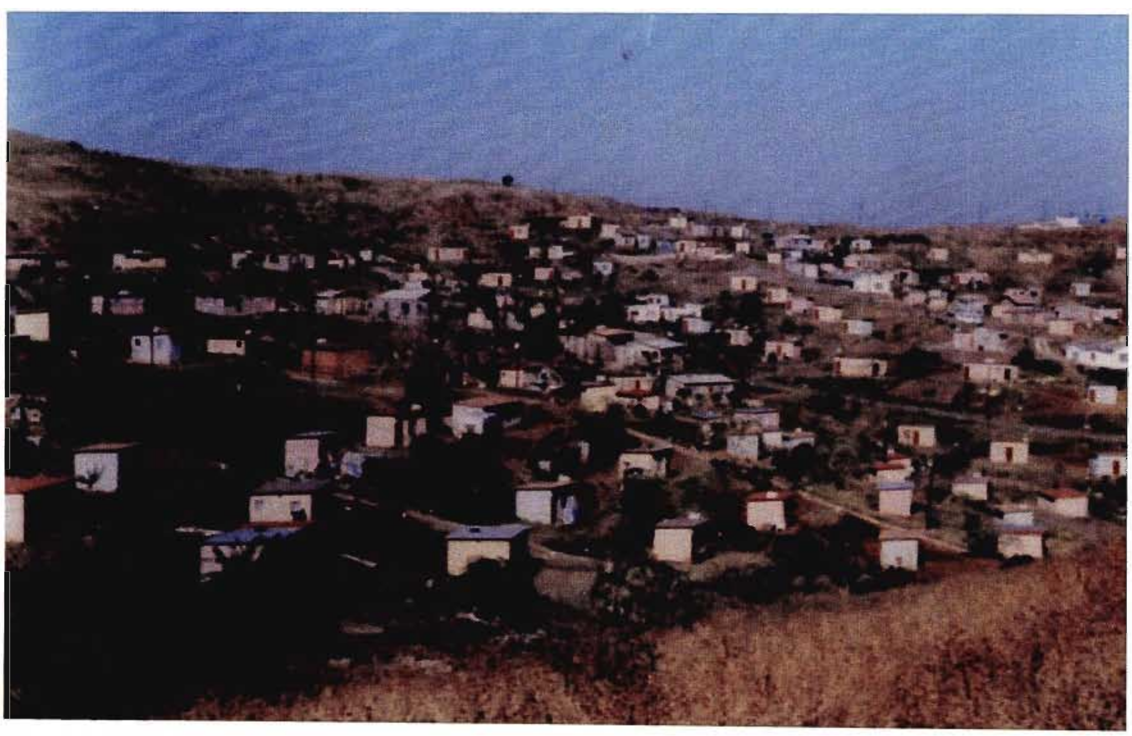


FIGURE 4 : Phases 1 and 4 of the Waterloo development, showing mostly 1 and 2 room dwellings.

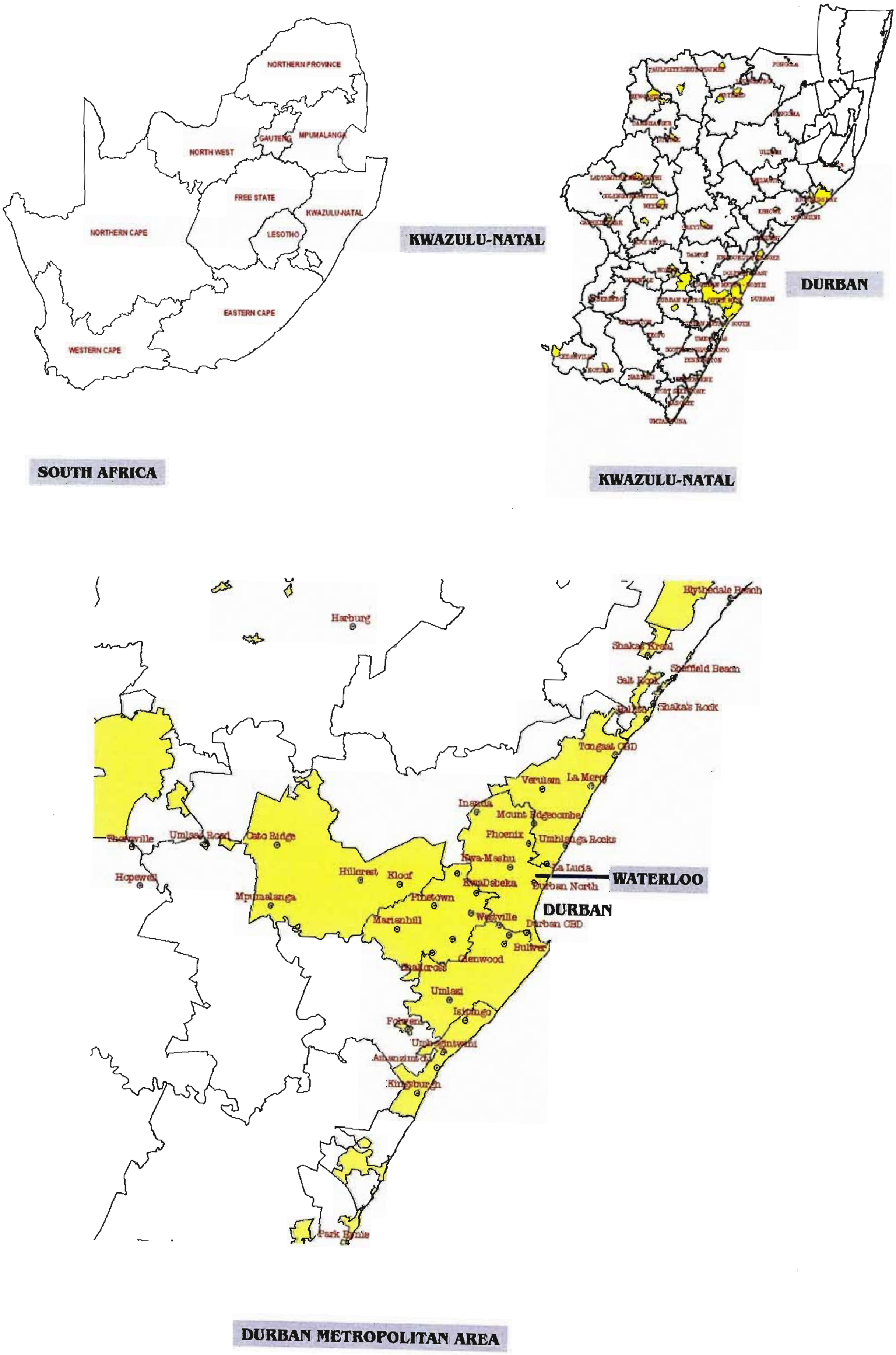


FIGURE 5:- The location of Waterloo in Durban Metropolitan area, KwaZulu-Natal, South Africa.

3.2 ETHICAL APPROVAL

This study was approved by the Ethics Committee of the Nelson R. Mandela School of Medicine (H092/01). Informed consent was also obtained from all participants in the study (Appendix 1). Prior to the study being implemented, several meetings were held with the community informing them of the proposed study and the plans for implementation. Initially, liaison was made with the waterloo Development Committee; a representative body of the community of Waterloo who supported the study. As the study was underway, several other role-players viz. councillors, Departments of housing and health were consulted with, thereby increasing intersectoral collaboration.

During the study, regular communication took place between the research assistants, discussing problem areas and finding solutions. The findings of the home survey and data derived from the questionnaires remained confidential, but were used in the analysis of the results. As a way of reporting back to the residents of the area, a report back workshop together with a circular (appendix 4a and 4b) depicting the salient findings of the study were conveyed to the residents and participants in the waterloo area.

3.3 SAMPLE SELECTION

One of the important aims of the study was to estimate the prevalence of dampness and mouldiness amongst the housing units currently occupied. The sample size calculation is based on the estimation of this parameter. We expect to observe a prevalence of about 0.42 (Sekotha *et al.,* 2000) and wish to estimate it with a 95% confidence interval – (0.37 – 0.47).

Thus,

$$n = \frac{p(1-p)}{e^2}$$

where p = sample proportion (estimated mouldiness prevalence)

e = required standard error

This gives a sample estimate of at least 375 housing units. A contingency measure of approximately 40% have been calculated for withdrawals and non-participation of residents, which adds to 525 dwelling units, of which 491 homes were successfully approached and surveyed. The study homes were selected using an area site plan as a guide. Every forth (4 th) home from the grid was used for the study, thereby forming the sampling frame.

3.4 A HOUSING AND BUILDING ASSESSMENT OF THE WATERLOO HOUSING DEVELOPMENT

Initially the applicants for homes were afforded a choice by the Local Authority to either build their own homes from pre-approved plans or for a building contractor to construct the unit using the prescribed plans. The housing department for the Waterloo development, under the guidance of the building inspectorate and architects have prepared nine plans of varying dimensions and styles that were offered to the applicants. The plans were drawn in compliance with the requirements of the National Building Regulations (1985).

3.5 VISUAL INSPECTION

Visual Inspection to the area and the selected homes, provided important information. The general condition of the dwelling, its walls, floors, design, materials, dampness, mouldiness; and also the conditions of the occupants health were all verified visually. There were aspects of the questionnaire that required more detailed answers which the applicant experienced difficulty with. The administrators visual assessment and inspections aided in gaining maximum information. Prior to the field phase being undertaken, the questionnaire administrators were trained at numerous sessions, both on and off field to familiarise them of the requirements for the study. The training sessions included *inter alia* :-

- Information on the purpose of the study
- How to enquire and gather information using the questionnaire
- What to look for in terms of dampness / mouldiness and building characteristics
- How to measure certain building characteristics viz. house size; area of dampness and mouldiness, etc.

3.6 SURFACE MOULD AND MOULD BIOAEROSOL SAMPLING

There are several different techniques for the quantitative and qualitative enumeration of the fungi in the built environment. The methods range from simple visual investigations and source sampling to complicated analytical methods of sampling. Air samples and surface samples were taken using a single stage Anderson sampler and sterile cotton swabs respectively. Duplicate samples were taken both from the living room and/or kitchen and the external environment.

All culture procedures were done in the laminar flow (Labotec) containing a UV light. Prior to work, the cabinet was swabbed/sterilised with a mixture of ethanol and methanol (70:30 v/v) solution. The cabinet hood was continuously on during the procedures to ensure the area was kept sterile. Dichloran–18% - glycerol (DG 18%) (Appendix 3) was prepared according to methods of Samson *et al.,* (1995) and as described in appendix 3, and autoclaved at 120° C and 121 kpa for 15 minutes. Chloramphenicol was added as an antibiotic. Mould air samples in the bedroom, kitchen and the external environment were collected using an N6 Andersen sampler (Andersen Industry, USA). Air samples for culturable fungi were collected at the approximate height of the breathing zone (1 m above the floor) and operated for a ten-minute duration. After each sample, the sampler was cleansed and decontaminated using a mixture of ethanol, before the placement of the next petri dish of media. All agar plates were taped, packaged in sterile bags to avoid contamination and transported to the laboratory. Surface samples were collected by swabbing the surface of walls and ceilings using pre-sterilized cotton buds (120° C, 121 Kpa. for 15 minutes). At the laboratory the samples were incubated at 25° C for 5 to 7 days in the Environmental Cabinet (Labotec). Fungal colonies were enumerated and identified

3.7 HEALTH OUTCOMES FROM THE QUESTIONNAIRE SURVEY

A health questionnaire was designed together with a consent for the participants and was administered to 491 households in the area (Appendix 1 and 2). The questionnaire was so designed as to gather information on the demographics, occupancy status, building conditions and health matters. Housing conditions were characterized with questions describing building construction, age of structure, and materials used. Apartment related factors included the use of fuels used for cooking and heating, ventilation, orientation and size. The head of the household; being the respondent, reported on smoking, water damage, presence of moulds, cleaning practises and occupancy. Most often, information was provided by the female adult; as the male was at work and was not present. The instances when the head being the male was present, he most willingly obliged and co-operated. Gathering health/medical data as per the requirement of the questionnaire, were provided based on present and existing conditions being experienced. The local clinic was used as a health institution for diagnosis. Although medical records were not analysed in-depth, minor ailments sought from the clinic were used as data.

The administration of the questionnaire was done by a trained research team consisting of members from the community. The administrators were educated in regards to public relations, questionnaire recording and general interpersonal communications. The 6 administrators were unemployed residents, living in the different phases of the area. This was advantageous as they were familiar with their neighbourhood. The administrators were continuously supervised in their performance, as the research was being conducted. The Residential addresses of all the homes that were visually inspected and questionnaire administered were noted and recorded. For identification purposes, a sticker was placed on the door of the dwelling. Prior to the commencement of the research, the householders were informed and consent taken, which enabled the interviewers have consent to interview occupants.

3.8 LEGISLATION

The following pieces of legislation were studied with respect to Indoor Air Quality :-

- The South African Constitution of 1996
- The Health Act No. 63 of 1977
- The Housing Act
- The Atmospheric pollution Prevention Act
- The Occupational Health and Safety Act
- The National Building Regulations

3.9 DATA MANAGEMENT AND STATISTICAL ANALYSIS

Data collected was analysed using the software packages of Microsoft Excel 2000 and SPSS for Windows. In order to assess significantly different data sets, the ANOVA test was used and significance differences were accepted at the 5 % ($p < 0.05$) level. These p-values have been quoted where applicable.

CHAPTER 4

RESULTS

4.1 QUESTIONNAIRE SURVEY

After the analysis of 491 questionnaires about 51 % of the dwellings surveyed had dampness (> 3 m^2) and 47 % had visible surface moulds, primarily on the walls (at least an average of 1 m^2). Preliminary results also showed that 53 % of the dwellings lacked proper ventilation as airbricks were absent, which has the potential to impact adversely on the health of the occupants.

4.1.1 BUILDING ASSESSMENT

The dwellings were constructed with SABS approved blocks / bricks and cement. The development currently is 6 years old and is steadily expanding. The average age of the dwellings was 3 years. The study has indicated that 230 (47 %) of the 491 dwellings were single/one roomed with a total floor area of $12m^2$. In these homes, was also a water closet inter-leading indoors, with a dimension of $1m^2$. The survey has indicated that of 491 dwellings, 233 (47.5 %) were dwellings built off the prescribed plans by the contractor and 258 (52.5 %) were owner – built dwellings, as indicated in Table 1.

TABLE 1 : Number of dwelling in the different phases.

PHASE	OWNER-BUILT	CONTRACTOR
1	60	11
2	97	36
3	76	140
4	25	46
TOTAL	258 (52.5%)	233 (47.5%)

The age of the dwelling indicated significant correlation with dampness (p = 0.002). It indicated that as the dwelling aged, chances of it being damp were increased. The study in Waterloo indicated that in 491 dwellings surveyed, 1178 rooms were habitable. The population that was accommodated in these rooms was 2414, with an average of 2 occupants per room.

4.1.1.1 WALLS

Table 2 indicates that 6-23% of the dwellings surveyed in the 4 phases had no wall covering, with the most being in phase 2 (23%). Buildings with no wall covering were found to be damp most routinely. Dwellings with wall plaster only ranged from 16–44%, while those not plastered, but only painted were between 11-52%. Phase 3 had the most number of dwelling that were only (n=113). Dwelling that were plastered and painted ranged between 22-39%, randomly in the 4 phases. Paints that were mostly used were PVA acrylic. Dwellings that were plastered and painted showed increased resistance to dampness. The overall conditions of the walls were as follows : 11% had no covering, 26% were only plastered, 32 % were painted only and 31 % were plastered and painted. Cross–tabulation between the conditions of the walls and dampness, showed significant correlation (p = 0.010). Walls that were plastered only had 41% reduction in mould occurrence and walls that were painted only had 43% reduction in mould occurrence. Dwellings that were plastered and painted, reduced the chances of mouldiness by 67%, to those dwellings that lacked plaster and paint coverings.

TABLE 2 : Summarised data on wall covering.

PHASE	NO COVERING	PLASTER ONLY	PAINT ONLY	PLAST&PAINT
1	12 (16%)	24 (34%)	8 (11%)	27 (39%)
2	31 (23%)	35 (26%)	16 (12%)	51 (39%)
3	12 (6%)	34 (16%)	113 (52%)	57 (26%)
4	4 (6%)	31 (44%)	20 (28%)	16 (22%)
TOTAL	59 (11%)	124 (26%)	157 (32%)	151 (31%)

FIGURE 6 : Wall covering of walls that were painted only (left) and plastered only (right), and the effects of dampness.

4.1.1.2 ROOFING

The most common roofing material used was asbestos (56 %), which served as a roof and a ceiling, followed by metal (39%). Cover-land tiles were used on 5% of the dwellings. Only 7 % of the homes were fitted with rhino-board ceilings, mainly in phases 1 and 2. The roofing of the dwellings did not show any significance in terms of dampness and mouldiness, but there was a significant correlation between ceiling dampness and mouldiness ($p < 0.05$). It was also noted that 53 of the 93% of dwelling without ceilings were damp and mouldy.

4.1.1.3 FLOOR

The floor covering of the dwellings is tabulated in (Table 3), which reflects that between 12% and 63% of the dwellings, (average=31%) had no covering on the concreted (granolithic) floor and between 31%-72% (average=51%) had vinyl. A small proportion of 39 households could afford carpets (8%) and tiles (10%).

The occurrence of "spring water" emanating from the foundation was a common recording. This seepage caused the dwelling to be continuously damp and moist.

TABLE 3 : Summarized data of floor covering

PHASE	NO.-HOMES	CEMENT	VINYL	CARPETS	TILES
1	70	22 (31%)	29 (41%)	7 (10%)	12 (18%)
2	133	60 (46%)	42 (32%)	9 (7%)	18 (15%)
3	217	27 (12%)	157 (72%)	22 (10%)	11 (6%)
4	71	44 (63%)	22 (31%)	1 (1%)	4 (5%)
TOTAL	491	153 (31%)	250 (51%)	39 (8%)	45 (10%)

4.1.1.4 VENTILATION

In terms of ventilation, most of the occupants depended on natural ventilation for air circulation in their homes and they did not have chilling systems to keep their rooms cool during warm to hot days. The most reliable means of allowing air to enter the buildings were airbricks, windows and doors. Although every dwelling was provided with at least one window and an entrance door, 261 (53 %) of the homes did not have airbricks. There were also situations where the only fitted window was not open-able, thus reducing the efficiency of adequate ventilation. Many cases (n=230) that were not in compliance with these requirements as tabulated in Table 4, and illustrated in figure 7. The minimum ventilation requirement, according to the National Building regulations is 5% of the floor area (National Building regulation, 1995).

FIGURE 7 : Interior of a dwelling indicating the absence of airbricks, and an asbestos roof which also serves as a ceiling.

TABLE 4: The prevalence of airbricks in the different phases.

PHASE	AIRBRICKS ABSENT	AIRBRICKS PRESENT
1	23	48
2	45	88
3	146	70
4	47	24
TOTAL	261 (53%)	230 (47%)

Cross tabulation of airbricks, dampness and mouldiness, using the Chi^2 test; showed significant association ($p < 0.05$). The absence of airbricks, and poor ventilation, promotes the occurrence of surface moulds.

4.1.2 HEALTH OUTCOMES FROM QUESTIONNAIRE

Table 5, shows the self-reported health complaints by occupants and their relationship with the lack of natural ventilation, dampness, mouldiness and the age of the dwelling.

Health is important in IAQ. The health issues of occupants that were of concern were; asthma (27 %); cough (25 %); sinuses (25 %); chest infection (23 %) and rheumatoid arthritis (7 %). Associations of cough with dampness and mould indicated no significant association ($\chi^2 = 0.109$ - $\chi^2 = 0.152$), respectively. It was also evident, though, that as the house age, moulds develop and prevalence of cough increases (I year =27% and 6 years = 38%). The incidence of asthma ranged between (18% - 35%), and was associated with the lack of airbricks/ventilation ($\chi^2 = 0.004$), dampness ($\chi^2 = 0.000$) and mouldiness ($\chi^2 = 0.000$). Mould with age of house, showed significant association with asthma, as a 1 year old house with mould had 18 % asthma, as opposed to a 4 year old house with mould = 36 %, and also indicated significant linear by linear association.

TABLE 5 : Results of health outcomes

Health Outcome	n = 491	%	Lack of Ventilation χ^2 (*p* value)	Dampness χ^2 (*p* value)	Mouldiness χ^2 (*p* value)	Age of Dwelling
Cough	122	25	0.57	0.10	0.15	0.57
Asthma	130	27	**0.00**	**0.00**	**0.00**	0.45
Wheeze	32	7	**0.00**	**0.01**	**0.02**	0.17
Bronchitis	12	3	0.25	**0.04**	0.11	0.12
Runny Nose	46	10	**0.01**	**0.01**	**0.00**	**0.01**
Itchy Eyes	56	11	0.46	0.22	**0.00**	0.15
Irritable Throat	21	4	0.40	0.37	0.50	0.15
Ear Infection	30	6	**0.00**	0.19	0.16	0.40
Mouth Ailments	8	2	0.82	0.16	0.19	0.33
Chest Congestion	113	23	0.82	**0.00**	**0.00**	0.60
Skin Rashes	61	12	0.17	0.14	**0.00**	**0.02**
Sinuses	121	25	**0.01**	**0.00**	**0.00**	0.20
Flu Symptoms	110	23	**0.00**	**0.01**	**0.00**	0.10
Allergies : -						
-Food	36	7				
-Dust	41	9	**0.00**	**0.04**	**0.02**	0.34

Tested using χ^2-test < 0.05 indicates a significant association.

Figures for wheeze ranged from 32 to 130 cases. In addition to the mentioned variables, the age of the dwelling also showed a significant positive correlation with runny nose (χ^2 = 0.010). Wheezing correlated with the lack of airbricks/ventilation, showed significant association and also significant linear by linear association (0.003). Wheezing was reported to be between 4% to 10% of the population interviewed, in dry and damp areas and between 5-10% in non-mouldy and mouldy areas. In the case of runny nose, a significant association was noted with lack of airbricks/ventilation (6-13%). Dampness and mouldiness also had a significant association with runny nose, between 6-14% for dampness and 9-19% for mouldiness. The age of the home also showed a positive relationship, 15 cases in the youngest and 32 cases in the oldest dwelling.

Dampness had a significant association with chest congestion, as in the absence of damp , there were 17 % chest congestion, and with damp, 35 % chest congestion and likewise for mould (18-29%). Mould with age of house, showed marginal association. In terms of skin rashes the ageing of the dwelling coupled with moulds showed a significant association, as ($\chi^2 = 0.522$), without moulds and ($\chi^2 = 0.022$) when moulds were present.

Dampness and showed a significant association with sinuses, as in non - damp cases, there were 16 % sinuses, and with damp; 34 % sinuses and likewise for mould (16-35%, $\chi^2 = 0.000$), also significant linear by linear association.

Dampness and mouldiness indicated significant association with flu like symptoms: ($\chi^2 = 0.012$), also significant linear by linear association. Significant association with moulds ($\chi^2 = 0.002$). Mould with age of house, showed significant association with flu symptoms as in the case of a 1 year old house with mould, having 42 cases of flu symptoms , as opposed to a 4 year old house with mould having 81 cases. The association reflect that dampness influences flu and increased by mouldiness. Slight association with the age of dwelling, but linear association indicates significant ($\chi^2 = 0.047$).

Dust allergy associated with lack of airbricks/ventilation showed significant association 4 to 13% of cases. Dampness and mouldiness also had a significant association ($\chi^2 = 0.046$). Increase in dampness lead to increase in dust allergy. Significant association with moulds ($\chi^2 = 0.029$). Mouldiness influences dust allergy and increased by dampness.

Table 6 shows that 70% of the households use electricity, followed by paraffin (7%) and gas (1%). Although electricity is the primary energy, it is mostly used for lighting purposes. 21 % of the residents used a combination of electricity, paraffin, wood and gas, which were probably more affordable in comparison with costs of electricity and the cost of appliances. The main uses of these energy types were heating, cooking and lighting.

TABLE 6 : **ENERGY FUELS USED IN WATERLOO**

ENERGY TYPE	NO. OF USERS	%
WOOD	3	1
PARAFFIN	35	7
GAS	6	2
ELECTRICITY ONLY	343	70
COMBINATION OF ALL	104	20

4.1.3 TEMPERATURE AND RELATIVE HUMIDITY

The climatic conditions in Durban are different from those of the other areas of the country. During the period of the study, the temperature ranged from 17° C to 28° C and relative humidity levels from 39 % to 57%. Temperature together with relative humidity readings, indoors and outdoors were taken, with the aid of an thermohydrometer.

4.2 ENVIRONMENTAL SAMPLING

4.2.1 SURFACE MOULDS, MOULD BIOAEROSOL AND IDENTIFICATION

About 51 % of the dwellings surveyed were found to be experiencing dampness (> 3m^2) and 47 % had visible surface moulds, primarily on the walls (at least an average of 1 m^2). Indoor fungal contaminant levels were higher than or comparable to outdoor levels. Predominant airborne fungal organisms identified included; *Aspergillus*, *Cladosporium* and *Penicillium* spp as illustrated in Table 7. Mould growth from condensation on windows were common, even in homes with low measured mould in air. Many of the sources of moisture problems were not related to condensation. Some of the problems were: bathroom splashing and wetting, basement water seepage from the soil, through the walls and foundation. Many of the observed moisture and mould growth problems are related to soil contact problems, in walls and floor slabs. Surfaces that separate the soil from the building must be designed and built to prevent wicking and seepage/ leaking of water, as well as infiltration of damp soil gases. Associations between these species and their occurrences in the specific rooms requires further investigations.

TABLE 7: Species of fungi and aerosol count, identified from the sampling process at different sample points.

CFU ANALYSIS

	Kitchen	Bedroom	Lounge	Outdoors
	n=56 cfu's3472	*n=59* cfu's =5810	*n=44* Cfu's=3089	*n=159* Cfu's=11593
Acremonium sp.	220 (6%)	250 (4%)	180 (6%)	790 (7%)
Aspergillus spp.	422 (12%)	660 (12%)	340 (11%)	1640 (14%)
Cladosporium sp.	1845 (53%)	2610 (45%)	1440 (47%)	5920 (51%)
Fusarium spp.	250 (8%)	250 (4%)	180 (6%)	720 (6%)
Sterile mycelia	515 (15%)	1950 (33%)	859 (27%)	2003 (17%)
Penicillium spp.	220 (6%)	90 (2%)	90 (3%)	520 (5%)

CHAPTER 5

GENERAL DISCUSSION

5.1 BUILDING ASSESSMENTS

The housing development was created primarily for residential purposes, Part C of the NBR, requires that any habitable room other than a kitchen, scullery or laundry shall have a floor area of not less than 6m^2 and the minimum horizontal dimension within such, shall not be less than 2m. Buildings separate their occupants from hostile external environments and create a better internal environment for them. Therefore buildings can be likened to human skin (a second skin) or an extention of our bodies as the third skin; that is the first skin and clothes are the second skin, forming a physical barrier to separate the inside from the outside (Schimmelschmidt, 1990; Walker, 1990).

Our ancestors paid much attention to the IAQ of a building. When choosing a location to build a house, they must consider the geomantic omen of the building. They were, sunshine; ventilation; terra and influence of the hill and stream path around the building. (Tonghua *et al.*, 2002). With the appearance of modern construction material in recent years, in order to seek for the luxury and excellent adornment, people ignore the harm of pollutants, radiation, carcinogen and asphyxiation caused by some adorn material, which leads some buildings to fall short of the basic requisition of health safety (Tonghua *et al.*, 2002). Building defects and failures often lead to the development of fungi and (biological) decay problems. The causes of decay in materials and structures and the effects of decay on the health of the occupants are influenced by the internal building environment which has a varied microclimate depending on the buildings structure and construction.

According to B1 of Part B of the National Building Regulations (NBR), which indicates the design requirements that any building shall be designed to provide strength, stability, serviceability and durability in accordance with acceptable principals of structural design and so that it will not impair the integrity of any other building or property; and the building to be so designed that in the event of accidental overloading the structural system will not suffer disastrous or progressive collapse.

5.1.1 WALLS

The inner and outer wall surface was meant to be plastered with cement and painted for protection from environmental factors, as required in Part K of the NBR, which was not always the case, and was to be complied with by the building contractor or owner-builder. In terms of water penetration, the NBR states that; any wall shall be so constructed that it will adequately resist the penetration of water into any part of the building where it would be detrimental to the health of the occupants or to the durability of such building.

5.1.2 ROOF

The deemed-to-satisfy requirements of the NBR, regarding roofs is that; it must resist any forces to which it is likely to be subjected; be durable and waterproof; not allow the accumulation of any rainwater upon its surface and as part of a roof and ceiling assembly provide adequate height in any room immediately below such assembly. A study carried out in Port Elizabeth, indicated that the most popular type of roofing was asbestos (39%); corrugated iron or zinc (29%); roof tiles (23%) and approximately 10% had Plastic, wood and hardboard (du Plessis, 1999), compared to the findings of our study, which were:asbestos (56%), Metal roof (39%) and tiles (5%).

The use of asbestos has been classified as potentially hazardous or inefficient materials for building a home. The ability of asbestos to hold water for a long period may increase level of water activity to be acceptable to some mould species (Sekhota *et al.*, 2000). Levin (1990) stated that due to large surface area, including internal surface of diameter of fibres, pores and cracks, asbestos has the ability of absorbing water as an insulator or acting as a condenser. Therefore asbestos is not a good building material to be used for roofing. It can be affected by high level of exterior humidity as a result contributes to high level indoor water activity (Sekhota *et al.,* 2000).

5.1.3 FLOOR

The construction of the floor of any structure is of great importance, and therefore should meet the underlying requirements :-

- Be strong enough to support its own weight and any load imposed upon such floor and be non-combustible.
- The floor of any laundry. Kitchen, shower-room, bathroom or room containing a WC pan or urinal shall be water resistant.
- The entire area with the foundation walls shall be covered by a suitable damp-proof membrane.

The limited dimension of the dwelling, and the provision of the sanitary convenience within, allowed for the emissions of odours and poor hygiene practices. The limited space, also allowed for the discoloration of the walls and the contents to be soiled by the pollutants emitted during cooking and space heating, by the use of coal, wood and paraffin as supplementary fuel sources to electricity. Granolithic and vinyl flooring increased the occurrences of moulds, whereas tiles reduced mouldiness ($p = 0.002$). The combination of floor moisture problems and vinyl as flooring material significantly increases the risk for health symptoms, such as allergic symptoms, sick building syndrome symptoms and airway infections (Bornehag *et al.*, 2001). Vinyl flooring material is common in Swedish dwellings and is more common in multifamily houses than single family houses. It has been reported that vinyl increases the risk of cough, "rhinitis" and "eczema" as compared with wood as floor material (Bornehag *et al.*, 2002).

5.1.4 VENTILATION

According to the National Building Regulations, the minimum natural ventilation requirement is 5% of the floor area and the minimum lighting requirement is 10 % of the floor area. While good ventilation is important and helps minimize the effect of small sources of pollutants, including excessive moisture generation by occupants, ventilation by itself is not the solution to serious problems. Preventing large source strengths of any pollutant, including moisture, is necessary for problem prevention. Houses cannot be healthy if they contain large pollutant sources. To be effective, ventilation must get to the bedrooms, so that pollutants generated by the occupants are carried away before they reach excessive levels.

Olivier (1988) stated that in a building with at least 1 airbrick per 1 m^2 of a floor area at a height of 1.75 m is acceptable for occupants. In a habitable room of a dwelling one air change per hour is required, but in the kitchen and bathroom three changes per hour are specified. Effective ventilation mechanisms must be able to replace polluted or stale air indoors by "fresh" or unpolluted air from the outside. The evidence of poorly ventilated buildings is not the amount of air that enters the building but rather the quality of air that flows indoors.

During the 1980s and 1990s an extensive advancement was made in research on the characterization of various chemicals and field measurements on the concentration of those chemicals in indoor space. Building owners have become much attentive to the use of building materials emitting various chemical substances harmful to the bodies, which made architects feel it necessary to avoid using those harmful materials for interior design. Many manufacturers of building materials are tending to produce non-hazardous materials in accordance with various reports issued by public media, so that their environmentally safe material could be selected by conscientious architects.

Everyone has the right to healthy indoor air and this right applies across the world. While it is an individual responsibility to prevent air pollution indoors, decision-makers both inside and outside the public sector have important tasks in this respect. Many factors influence indoor air quality, including the design, construction, equipment, operation and maintenance of buildings or other indoor spaces, and all that are associated with building or other indoor space bears responsibility for healthy indoor air and the protection of health. Awareness of the health significance of good indoor air quality is low in many societies, mainly because sufficient information is not available to those affected. In modern societies, exposure to indoor air results in more contact with many environmental contaminants than exposure to food, water and outdoor air. However, the laws protecting people from harmful exposures indoors are less developed than regulations concerning ambient air, drinking-water or food quality. This potentially increases inequalities in health and aggravates health risks in the less informed, poorer parts of the society and amongst the most vulnerable groups.

Generally, indoor air quality studies often evacuate the issues of odours and smell, probably because of the difficulty to describe odours (and the difficulty of measuring them directly) and because of the general problem of modern, western society with odours. Philosophers have considered the olfactory senses as inferior to vision and hearing (LeGuerer, 1994). Odours were associated with animality, primary instincts, sexuality and often-social discrimination (the poor smelled bad). At the same time doctors and scientists were extremely interested in odours even if they attributed them a wrong significance over centuries (odours were nearly identical to disease). In the eastern societies there has been a considerable collective olfactory culture (Ohloff, 1994). In India, China and Japan the art of scents has been extremely differentiated from well smelling building materials, perfumed (smoked) cloth, body perfumes to "scent clocks", "scent competition" and the traditional "scent hearing" of the "kodo".

The results suggest that the occupants are exposed to dampness and fungal bioaerosols in their dwelling, which may be impacting negatively on their health. Some practical tips to improve Indoor air quality include :-

- Smoking cessation
- Regular maintenance of furnace
- Reduce moisture and mould in the home by repairing roof and foundation cracks
- Grade soil to allow water to flow away from the house
- Dehumidify the dwelling, if necessary
- Reduce the amount of stored material in the house

- Choose building and renovating material with low levels of chemical emissions
- Avoid the use of pesticides.

5.1.5 THE RELATIONSHIP BETWEEN BUILDING MATERIALS, DAMPNESS AND MOULDS

Improved workmanship and materials selection on the builders part is also recommended. There is also a need to note that communities, although ignorant and not well informed still take the precautionary steps to live healthier, and it is imperative that laws and regulations be formulated at national and international level to assist the communities and promote healthy living (Gansan *et al.,* 2002). In many moisture-troubled or damp houses it is apparently not the occupants, but the houses themselves, that are responsible for the large moisture source strengths that seem to drive biological contamination, including mould growth. Most houses cannot process large amounts of moisture without getting into moisture, mould and dust mite problems. Local moisture sources and problems were a better predictor of visible mould growth than relative humidity.

Water tightness should be pursued as vigorously as air tightness, in both new and existing houses. Occupant moisture generation behaviour was not a good indicator of measured moisture source rates. Problems with the houses itself were often the source of moisture, including unplastered walls, rising damp, and poor workmanship. The contaminated and damp homes were smaller in size and had more occupants than recommended, so they had higher occupant densities.
According to Canada Mortgage Housing Corporation (CMHC,2003); mouldy areas can be estimated as follows :-

- "small area," if the patch is no larger than a square

  meter. There should be no more than 3 patches, each patch smaller than a square

  meter. Small mouldy areas may become larger over time, if ignored; so it is important to clean and remove, with the use of a detergent solution, household rubber gloves and a dust mask for protection.

- "moderate," if there are more than 3 patches, each

  patch smaller than a square meter, or there is one or more isolated patches larger than a square meter but smaller than 3 square meters (size of a 4 X 8 foot sheet of plywood).

- " extensive," if a single patch of mould is larger in

  area than a sheet of plywood. Being exposed to this much moulds is not good and must not attempt to clean up large areas by oneself. Professional help should be sought to determine why the mould is there in the first place.

If moisture from the outside is continuously entering the building, repairs to the building envelope is required. At the same time, steps should be taken inside the home to reduce the occupant's exposure to moulds. Below are some points to consider when addressing mould problems: -

- Discard mouldy or damaged material. Furnishings such as, mattresses, carpets, sofa's that have got wet or have been stored in damp conditions, should be discarded.
- Proper vacuuming reduces the amount of mould spores. All surfaces in the home (floors, walls, ceilings, shelves) and non-washable furnishings (sofa's, chairs, etc.) must be vacuumed thoroughly.
- Keep moisture generated within the home to a minimum.
- Pull carpets and furnishings away from the wall that get wet. Carpets and under felts that are mouldy, should be cut off and discarded.

- Take steps to dry up the areas that get wet.
- If the mould is limited to one area, isolate the area if possible. Cover the affected area with plastic sheeting secured at the edges. This is a temporary measure to minimize exposure.
- Healthy individuals can regularly clean "small" and "moderate" areas of mould.

The results suggest that the occupants of the Waterloo Low-cost Housing development are exposed to dampness and fungal bioaerosols in their dwelling, which are impacting on their health. Further research is required to improve building construction and design in this low-cost housing development. With regards to bioaerosols sampled, there were various fungal species identified. The ratio between indoor and outdoor counts are way below the levels of concern, because the outdoor is the source, but the enumeration of surface moulds are cause for concern. *Cladosporium* spp. was the predominant mould followed by, *Aspergillus, Penicillium, Acremonium and Fusarium* spp. respectively.

The ideal way of reducing the growth is to use mould-free material or fungicides that will not create any secondary complication and to improve ventilation. These measures, however, are not favoured because of cost constraints. Although this study has found and made known many relevant and significant health issues, future research and studies into other types of developments and building characteristics are required to draw comparisons and evaluate data.

5.2 EFFECTS OF IAQ ON HEALTH FROM THE QUESTIONNAIRE SURVEY

5.2.1 OCCUPANCY

The dwelling, irrespective of its state of construction, provides accommodation to the occupants. A drawback to this situation is that firstly, the dwelling most often is accommodating in excess of its required occupancy, resulting in congestion and related diseases. In terms of accommodation and occupancy the study indicated that in 491 dwelling units, there were 1178 habitable rooms, which accommodated 2414 occupants. One hundred and seventy four (174) out of 231 (75 %), 1 roomed dwellings accommodated in excess of 2 occupants. This calculation averaged that 2.05 occupants were occupying a room, which is in excess to indicators retrieved from other studies. Assessing the views of the occupants regarding congestion and overcrowding, also raised concern in that they expressed the loss of privacy and independence. Their family lifestyle is impeded.

Crankshaw & White (1992) showed that a rough indicator that more that 1.5 people per habitable room would be considered overcrowded, and more than two per room should be regarded as very overcrowded. This is a fact that plays a significant role in assessing lifestyle of occupants in a home. Overcrowding in residential and non-residential buildings may be associated with illnesses, for example, dizziness, fatigue and tiredness (Oxley & Gobert,1994). Individual householders have extended their dwellings to accommodate more occupants or to live more spaciously. The reasons for extension or alteration may differ from one family to another, due to the financial implication. The socio-economic status of the occupants plays an important role in determining the quality of lifestyle in the various homes. The size and number of rooms per home must be proportional to the number of occupants in the home.

It is well known that the level of overcrowding in a building is a common phenomenon especially in low cost housing for example shacks (Gqaleni *et al.,* 1999). Living in a multifamily house increases the risk for nearly all allergic symptoms, compared with single family houses (Bornehag *et al.*, 2002). The possible psychosocial implication of crowding range from discomfort and stress to domestic violence and rape. Other health consequences include increased rates of transmission of infectious diseases. While it is generally accepted that overcrowding has numerous adverse psychosocial and health implication; more detailed studies are necessary to fully understand specific issues and health risks, in the local context.

5.2.2 TEMPERATURE AND RELATIVE HUMIDITY

The climatic conditions in Durban is different from the whole of South Africa. During the period of the study, which was winter; the temperature ranged from 17° C to 28° C and relative humidity levels from 39 % to 57%. The temperature and relative humidity inside most of the homes in the area can support a wide variety of organisms. Areas with low percentage equilibrium relative humidity (ERH) values would also support onset of sporulation by inducing stress on the organisms (Gqaleni *et al.*, 1996). This will increase mould bioaerosols levels within the indoor environment. Hence, temperature and relative humidity affect concentration of the spores with change in season.

The availability of water to fungi in a given building material depends on the materials equilibrium relative humidity (ERH) or water activity (a_w). As ERH (a_w) increases, more species of fungi are able to grow more rapidly. At 100 % ERH (1.00 a_w) water is freely available. Relative humidity (RH) is a measure of the actual moisture content of air compared with the saturated moisture content at that temperature. Air moisture content or vapour pressure (VP) is a temperature-independent measure of the total quantity of moisture (water) in the air. If no water is added to the atmosphere, increasing temperature decreases relative humidity. Relative humidity in the home should be under 45 % in the winter (or lower to avoid condensation on windows). If necessary, use a dehumidifier to lower the relative humidity (CMHC, 2003). Physiologists testified through research that indoor temperature and humidity have close relationship with inhabitant's health, work, study and living. Too high temperature will affect the thermoregulation function, results in body temperature rise, blood vessel expansion, and pulse rapidness, heart acceleration. While too low temperature will cause metabolic function decline, pulse and respiration slowness, blood vessel under the skin contracting, skin straining, and place a premium on disease of the respiratory tract. Scientists limit the indoor temperature in the scope from 11^0 C – 32^0 C. At the same time, indoor RH should also be paid attention to. In summer, when the humidity is too high, body's dispelling heat will be oppressed and the occupant will feel sultry and fretful. In winter, when the humidity is too high, heat conduction will accelerate and people will feel gloomy and cold, depressing, throat aching, voice hoarseness and nose bleeding, and easy to catch a cold. Specialist believe that the upper limit of humidity should not exceed 80% and the lower limit should not be lower than 30%. Experiments shows that the suitable temperature and humidity are as follows: - temperature is 18 to 23^0 C, humidity is 30 to 80% in winter and temperature of 22 – 26^0 C, humidity of 50 - 70% in summer.

5.2.3 HEALTH OUTCOMES

Of the 491 dwelling units surveyed, statistical analysis revealed that there are significant associations between lack of ventilation; dampness and mouldiness with a host of health outcomes especially: asthma, wheeze, runny nose, sinuses/flu symptoms and dust allergy, all having $p < 0.05$. Comparing the self-reported results from the questionnaires to other studies, it was noted that similar findings were documented. High exposures to air pollutants have been associated with a host of respiratory diseases including acute respiratory infections (Smith *et al.,* 2000), chronic bronchitis (Perez-Padilla *et al.*, 1996) and tuberculosis (Mishra *et al.,* 1992). Reported asthma is not as accurate as clinical measures of asthma. Also, because the disease carries a stigma, reported prevalence of asthma may be an underestimate due to intentional concealment or lack of knowledge, especially for children and young adults. For the elderly, however, there is not much stigma attached to the disease and it is not considered contagious like tuberculosis, so underreporting due to intentional concealment should not be a major problem. There is also a possibility of over-reporting because some other disease condition with similar symptoms, such as chronic bronchitis, may be reported as asthma (Mishra, 2002). Asthma prevalence, morbidity and mortality are increasing in the United states and other nations (NIH, No. 91, 1991). During the 2 year period 1993-94, there were an estimated 14 million people in the United States with a chronic asthma condition (Benson, 1994).

Living in a damp and mouldy abode for prolonged durations exacerbate the occurrences of wheeze. For example, between 47 to 84 cases were reported comparatively within the youngest and oldest dwellings. Dampness .and moulds influences wheezing. When associating bronchitis with the variables, there were not strongly associated, and therefore did not warrant much concern. The strongest of the associations however, was with dampness. Dampness and mouldiness indicated slight significant association with itchy eyes, in that when there's no damp/moulds, 8% cases of itchy eyes occurred and with damp/moulds, cases of itchy eyes was 10%. Mould and age of house, showed significant association. Dampness and mouldiness are associated with itchy eyes. When associating chest congestion, there were no greatly significant association with lack of airbricks/ventilation, as in the absence of airbricks/ventilation, there were, 24% as opposed to 21% cases of chest congestion.

Skin rashes did not reveal significant association with lack of airbricks/ventilation, but moulds were significantly associated; 22 (8%) cases of skin rashes as opposed to 39 (17%) when moulds were evident. Sinuses indicated significant association with lack of airbricks/ventilation, dampness and mouldiness. Adequate ventilation resulted in decreased sinuse blockage by 10% i.e. from 30 to 20%. Mould with age of house, showed significant association with sinuses blockage, as a 1 year old house with mould; there were 42 cases of sinuses, as opposed to a 4 year old house with mould = 81 cases. Dampness influences sinuses and increased by mouldiness.

Cases of flu symptoms were less in houses with airbricks (17%) than those with not (27%). In terms of allergy, food and dust allergies were of concern. In total, 79 people had allergies that were due to food (n=36, 46%); and dust (n=41, 51%) respectively; and a very minute percentage (3%) suffered from eczema. The consumption of grainy foods especially nuts and vegetables were the causative factors for the occurrences of food allergy. Food allergy affects between 5% and 7.5% of children and between 1% and 2% of adults. As many as 39% of American adults self-report food allergy and alter their eating habits according to Sloan and Powers (1986). The spectrum of food allergy ranges from cutaneous symptoms, such as atopic dermatitis. These appear several hours after the ingestion of the responsible food to potentially life-threatening symptoms occurring immediately upon ingestion. Biological contaminants include bacteria, mould, mildew, viruses, animal dander, mites, cat saliva, cockroaches and pollen. This wide variety of biologicals come from a number of sources. It is not a nice thing to think about, but the protein in rat urine is a powerful allergen. When it dries, the urine can become airborne and distributed throughout the house by central air moving equipment.

Dust allergies (51%) are mainly experienced when dust particles becomes airborne during road traffic and housekeeping. The floors (31%) being without appropriate covering (Grano); serves as suitable surfaces for the accumulation of dust and other respirable particles. During manual cleaning, the particles becomes airborne and cause an irritation to the respiratory tract.

Moisture related problems, growth of fungi and an abundance of house dust mites harm the health of occupants (Gunnarsen *et al.*, 2002). Increased moisture levels in a microenvironment have been shown to increase the prevalence of both fungi and house dust mites (Cunningham, 1999). Therefore, increased growth of moulds and proliferation of house dust mites in moist rooms may partly explain the health impacts (Jaakkola *et al.*, 1993). House mites are the most important source of inhalation allergens in homes. House dust mites require certain temperatures and high humidity in their microenvironment. They feed on human skin scales found abundantly in most homes and thrive from elevated moisture contents. It is difficult to remove mites from protected environments such as mattresses, wall-to-wall carpets or textured upholstered furniture. Normal cleaning procedures are more likely to remove mites from smooth surfaces. The mites move around and in infested rooms they are found on most surfaces (Korsgaard, 1983). Surface dust acts as an adsorbent of volatile and semi-volatile organic vapours (VOC, SVOC) and as a carrier of detergents, plasticizers, pesticides and microbial toxins (Wolkoff *et al.,* 1998).

Although the study was not designed to address health issues in detail, the condition of rheumatoid arthritis attracted much concern. There were 6.7% of homes (33/491), experiencing conditions related to rheumatoid arthritis, which were self reported. The predominant phases were 1and 2. One of the probable causes may be attributed to the floor covering as 31% of floors in phase 1 and 46% in phase 2 were of cement only (granolithic).

In the study conducted, there were 32 cases (7%) of cases of tuberculosis. Greater prevalence of tuberculosis were in Phase 3 (14 cases) and followed by phase 2 (11 cases). Poor ventilation, with the absence of airbricks, Phases 2 = 65% and phase 3 = 33%, may be one of the contributing factors. As discussed above, the issue of overcrowding as a factor, inadequate living space and congestion were experienced in phase 2 and 3, where more than 4 were accommodated per room. The mean allowable number is 2 per room. But this survey indicated that 2.05 were accommodated per room, therefore congestion and overcrowding were experienced

Listed hereunder are other aspects of health that the residents of the waterloo area expressed concern.:-

- Many residents showed great interest in Rheumatoid Arthritis, as there were 33 cases experienced, mainly in Phase 1, where 31 % of the floors were cement and no proper covering. There is however a difference between arthritis and rheumatism, which created some degree of confusion. This area still requires further investigation.
- Concern was also indicated by the high rates of Tuberculosis (32 current cases), This health condition is related to many factors, viz. ventilation, smoking, pollutant emitting fuels used, living in congested abodes, nutrition, etc. One of the many factors that require urgent addressing, is the congestion issue. There were cases of up to 11 people living in a single roomed dwelling, which is under great congestion. The present AIDS epidemic, which is increasing and impacting at a great pace was also of local and global concern. Recording 2 positive cases of AIDS in this study, which was medically diagnosed and self-reported; brings to mind gaps that promote this and related diseases. Many residents expressed their lack of privacy and independence, as the entire family

unit disrupts and witnesses their "romantic activities." The most common cause of this situation was unanimously echoed as the size of the houses being inadequate

5.2.4 ENERGY USE

Unprocessed biomass fuels are still one of the most common fuels in the world. It is estimated that around 50% of the world's population, and more than 75% of those living in developing countries rely on biomass fuels (Reddy *et al.,* 1997). At least 2 billion of the world's poorest people are still primarily dependent on biomass fuels (World resources institute, 1998). The use of these fuels indoors on open fires and inefficient stoves with poor ventilation leads to high levels of smoke exposure and increases the risk of a range of important health problems, including pneumonia (Smith, 2000) and chronic obstructive lung disease (Bruce, 2000).

Globally, interventions to reduce exposure to Indoor air Pollution have been largely "technical" in nature. Interventions have either focused on improvement of existing appliances (eg. The provisions of improved chimneys), or the introduction of new technologies (eg, new braziers for space heating) or the promotion of cleaner, more efficient fuels (eg. Electricity). The technical interventions have proved to be unsustainable largely because of the cost implication for the user. In a survey conducted in Sebokeng, continuing use of coal for space heating and cooking was reported in 48 % and 45% of electrified households respectively, (Terblanche, 1998). The use of electricity is similar to Port Elizabeth, where 72% of the households have access to electricity, which is often used for lighting (Urban Environment series report No. 6).

There are many reasons explaining the delay in the transition from solid and liquid fuels, up the "energy ladder," to the exclusive use of electricity. The primary reason is that the poor do not have the financial resources to use electricity exclusively for all end uses. Irregular, low and in some cases non-existent household income, necessitates energy use patterns that can cope with this. In addition, the secondary costs of electrical appliances become an extra burden on households with limited financial resources. Banks, Mlomo and Lujabe (1996), have also identified certain social, cultural determinants as important reasons for the delay in the exclusive use of electricity. For example; people often equated cooking with wood and/or coal as having particular cultural significance. Wood and coal has always played a role in bringing the family together in the evenings. Fire is seen as an important factor in fostering communication between families. In addition, many respondents indicated that their food was tastier, when cooked on an open fire. Paraffin also plays an important role in the sharing of resources and communal cooking in times of financial hardships. This is said to increase community 'spirit' between households.

In a country like India, the problem of IAQ faced by a huge population is the usage of biomass as cooking fuels (Saksena, 1999; Prasad *et al.*, 1992). It is estimated that 76% of total households and 90% of rural households in India still rely primarily on biomass fuels. It has also been estimated that 410 000 – 570 000 premature deaths annually occur in India from Indoor air pollution, exposure to children under 5 and adult women (Smith, 1998). To overcome this problem, the most widely applied intervention is the introduction of improved stoves that emit less pollutants than traditional stoves. The government of India's National programme of improved cook-stoves (NPIC) has introduced some 33 million biomass based improved stoves in the rural areas during 1984 – 2000 (Indoor air Pollution, ESMAP, Newsletter, 2001).

In a study by Mika (2002) in Zimbabwe, two new stove programmes were implemented, whose primary objectives was to conserve fuel wood as a solution to the scarcity of domestic fuels and stopping deforestation. The success of the programmes has been limited, due to a number of socio-economic problems such as functional acceptability, poverty and the inability to pay for improved stove, poor product quality, poor marketing and scarcity of appropriate raw material. Although most of the results from the study were of qualitative nature, the extent of smoke problems was found to be substantial. Fuel wood is the dominant source of energy with more than 90% of the households using it for cooking or heating purposes.

Observation of smoke discolouration on the walls in the kitchen showed that 74% of the households had medium to high incidence of smoke with the rest having low incidence. 80% of the sampled households agreed that smoke is a problem as it causes eye irritation, coughs, flu and headaches. Ventilation was insufficient due to strong belief that opening of vents or windows provides witches with easy access to kitchens. Even though smoke is a problem, the households also indicated that it had its advantages. They felt that smoke was beneficial to them as it makes the wooden poles and grass thatch last longer. The soot is applied to wounds to dry them, taken with water it treats stomach pains and is medication for ailing cattle.

Many households use potentially dangerous fuels and appliances in part because of their poor incomes, and in part to their limited access to suitable fuels. A retrospective analysis undertaken on 194 patients admitted to the Burns units at Woodstock Hospital, Cape Town, between January 1990 and June 1992, found that 33 patients sustained burns because of working with primus stoves. What was notable is that these patients were all black men and women, with an average age of 32.5 years (range 14-68 years). Fires that involve energy sources such as wood or paraffin account for 75% of serious injuries in childhood occurring in informal settlements, and are responsible for 21% of child deaths (Mehlwana, 1998). Paraffin is used widely by many low-income households because of its versatility and ability to perform multiple tasks simultaneously.

5.3 ENVIRONMENTAL FACTORS

Concerns pertaining to the environment and locality that surfaced from the study are as follows :-

- Of an environmental nature, there was increased concern of the noxious odours experienced almost the entire day, which probably emanated from the sewer treatment works. To 35% of the residents, this posed a problem in terms of comfort. Methods and procedures of treatment, require examination.

- Vermin, viz. flies, ants, cockroaches and snails, in all phases were experienced (32% of the household complained).
- The open drainage systems, open manholes, and the stagnation of water thereof, created excellent grounds for mosquitoe- breeding, which is a constant problem.

The findings in this study showed that poor ventilation, overcrowding and poor building designs and workmanship contribute to indoor surface moulds and dampness. The number of airbricks and lack thereof, indicated the poor ventilation that exists in the dwellings. The ratio between the number of occupants and rooms per house were also insufficient. With regards to the dwellings and their structures, the homes should be constructed and delivered with the health of the occupants in mind. The inadequacies arising from the absence of airbricks, windows, poor foundations, lack of proper and impervious wall and floor covering, all have a bearing to the lifestyle and health of the occupants.

5.4 INDOOR AIR QUALITY LEGISLATION

The aim of the Health Act No. 63 of 1977 is to provide for measures for the promotion of the health of the inhabitants of the republic; to that end to provide for the rendering of health services; to define the duties, powers and responsibilities of certain authorities which render health services in the republic; to provide for the co-ordination of such health services; to repeal the public Health Act, 1919; and to provide for incidental matters.

The Kwa-Zulu Natal Housing Act was established to provide for a sustainable housing development in the province within the framework of National and Provincial Housing Policy. Although there is a shortage of housing in the country and the government sector is implementing mechanisms to reduce the shortage by providing to the homeless, the provider must take cognisance of the fact that the dwelling that is built and provided for must promote the health of the occupants and not be a source of ill-health and diseases (Gansan *et al.*, 2002). Take for example, a housing scheme is planned aimed at alleviating the present housing crises. Such a plan contributes to meeting the targets of the Housing Act. However, it must be borne in mind that provision of housing is not an end on its own, healthy housing should be the ultimate goal. This means the focus should not only be on the number of houses constructed, it should also focus on quality.

The Atmospheric Pollution Prevention Act comprises of 6 important parts which can be summarized as follows :-

Part 1: The establishment and functions of the National Air pollution Advisory Committee.

Part 2: Control of noxious or offensive gases – This part deals with conditions in industrial and occupational settings, where the government designates control areas and authorize scheduled processes.

Part 3: Atmospheric pollution by smoke – this function is delegated to the Local Authority. There's focus on industries, however, section 14 provides for fuel burning appliances in domestic abodes and the use of fuels (18,d).

Part 4 : Dust Control in Mines.

Part 5 : Air Pollution by fumes emitted by Automobiles

Part 6 : General provisions of the Act.

There are several aspect of importance that are omitted in the legislation, and which may be construed as weaknesses of the Act :-

- There should be emphasis placed on smoke control regulations that apply to residential areas, especially poor neighbourhoods located in close proximity to industries.
- Local Authorities are most often faced with complaints regarding dust, which is out of their jurisdiction of control.
- There are no provisions made for the control of volatile organic compounds and fugitive emissions.

- There are neither set air quality standard nor any consideration to environmental impacts.

South African legislation is not very prescriptive when it comes to indoor Air Quality. The Occupational Health and Safety Act is based primarily on an industrial approach. Standards from other countries are sometimes used for these purposes, but they have the power of recommendation rather than enforcement, although the protection of an employee's health and safety is still to be enforced. People spend more that one third of their daily life at work attempting to go at it as comfortably as possible with emphasis on an acceptable level of fresh and safe air supply at all times. It often happens that the employer's provisions fall short of employee expectations concerning indoor air quality, (Nortier, 2000).

With reference to Indoor Air Quality, the National Building Regulations has guidelines that stipulate minimal requirements for ventilation. The minimum ventilation requirement for a room is 5% of the floor area of that room and 10% of the floor area is the minimum lighting requirement. A few practical problems that are associated with buildings not conforming to the specific guidelines that are enshrined in the National Building Regulations are :-

- Inadequate supply of purified indoor air due to the poor installation of open-able windows and doors.
- The selection and installation of building furnishings must be done in the interest of the occupants and their health.
- Cross ventilation in a building allows for an increased exchange of air.
- Poor design and construction of the building also leads to health effects.
- Building design, should also promote health and well-being. The heights of ceilings and roofs must be designed as to allow for maximum air exchange.

There is convincing evidence that poor IAQ is damaging people's health. The current piecemeal approach is ill - suited to achieving adequate progress on problems as complex and inherently multidisciplinary as the indoor environment. One of the major challenges noted is the fact that there is little data on the cost and benefits associated with healthier indoor environments. A dedicated effort is needed by government, industries and other key stakeholders to develop a standard set of indoor environment health indicators. This would allow for comparisons of different materials and assessments of the overall health of building. Such efforts to develop a standardized set should be harmonized with similar efforts taking place in other countries. Government should commit to developing policies that support voluntary initiatives, particularly in the areas of healthy housing, product labelling, emission guidelines, codes of practices for services, health claims and exposure standards. Associations and agencies should target outreach and education on indoor environment issues to health professionals, physicians, teachers, parents and building professionals.

-There should be more resources to research, especially in determining-

-The number, significance and sources of indoor pollutants

-The mechanisms by which people are exposed to them

-The health effects arising from prolonged and intermittent exposure to low-level concentrations of pollutants

-The health effects for at-risk population such as children and seniors

-The most cost-effective strategies for reducing pollutants sources, exposure and adverse health effects

Indoor air quality and Health is essential to sustainable development in any country. In many States environmental protection would still be a mere political catchphrase without content or specific shape today, if it were not for the communities environmental interventions. There is also a need to note that communities, although ignorant and not well informed still take the precautionary steps to live healthier, and it is imperative that laws and regulations be formulated at national and international level to assist the communities and promote healthy living. The fact remains that while a case can be made for supranational laws for pollution without boundaries, one nation's internal pollution is another nation's cultural tradition. Whatever the transnational element in air pollution, indoor air pollution is rightly a national concern.

5.5 INDOOR AIR QUALITY LEGISLATION AND HOUSING IN OTHER COUNTRIES.

In the United States the first effort made towards air quality legislation was the Clean Air Act of 1970. The Act utilized the partial pre-emption strategy, the EPA establishing the air quality standards and the states assuming primary responsibility for implementation. The Act mandated the regulation of seven pollutants : particulates, sulphur dioxide, carbon monoxide, nitrogen oxide, ozone, hydrocarbons, and lead. Primary standards were to be set so that the health of the vulnerable, especially the elderly and children would be protected within an adequate margin of safety. Presumptively, if the vulnerable were protected than the standards would be adequate to protect the general population. Secondary standards were to be established protecting such things as visibility, buildings, crops and water. Together the two types of standards constitute what is referred to as National Ambient Air Quality Standards, or NAAQS. The Clean Air Act and its 1977 and 1990 amendments are based in the command-and-control regulatory strategy and utilize partial pre-emption as the intergovernmental instrument.

In Great Britain, responsibility for air quality is vested in the Alkali Inspectorate. The inspectorate was established in 1863, predating by far the American EPA. The standards to be applied by the Inspectorate is associated with the concept of "best practical means" (b.p.m). This standard was established in the Alkali Act of 1906 and was made a part of the Health and Safety at Work Act of 1974. This Act provides that all firms are "to use the best practical means for preventing the emission into the atmosphere from the premises of noxious or offensive substances and for rendering harmless and inoffensive such substances as may be so emitted." The inspectorate has come under substantial criticism on several grounds. A key ingredient of criticism of the Alkali Inspectorate has been that, "it is an inaccessible, secretive and uncommunicative organisation" (Hill, 1982).

Indoor air regulations exists in many Nordic and Central European countries as well as the United States and Canada. In countries other than Finland, the problem caused by moisture and microbial exposure is considered a health risk but is not mentioned in legislation, (Husman, 1999). In the United States, recommended values are given for ventilation rates, particulates, and several chemicals in indoor air but not for microbes. In other European countries eg. The United Kingdom, microbial growth and moisture in buildings are considered potentially harmful to health, and recommended values for relative humidity, particulates and ventilation rates are given as well as for control of moisture in buildings. In Germany, house dust, micro organisms and other allergens are considered health hazards, and measures are given for avoiding these risks. In Sweden, moulds and other moisture related microbes are considered health risks, but no recommended values nor regulations are given. The Swedish National Action Plan states that "no-one should need to risk sickness or symptoms caused by defective indoor environments." (An action plan for Sweden, 1996).

The problem of inadequate or nonexistent housing has reached critical proportions globally. The world population passed 6.1 billion in 2001 and is expected to reach 7.9-10.9 billion by 2050, according to the United Nations (UN) Population Fund. This sheer volume alone exerts enormous pressure to improve existing housing and create new homes. As the global population grows, rural areas around the world are emptying and mega-cities springing up, usually as unregulated districts circling an older, more organised core (Brown 2003).

In the 20th century, housing as a key policy issue gathered momentum internationally at the 1976 UN conference on Human Settlement. The main idea was that housing and shelter should be a human right....because it should not only provide protection from harsh or severe environmental conditions, but also access to clean water and sanitation. The UN has included the right to safe, healthy housing in a number of international declaration, such as the Universal Declaration of Human Rights (1948), the International Covenant on Economic, Social and Cultural Rights (1996), and the International Covenant on Civil and Political Rights (1976).

In October 2002, president Bush awarded nearly $95 million in Healthy Home Initiative (HHI)-funded grants to cities, countries and states to increase the removal of lead based paint hazards from housing and to support research and pilot programs aimed at mitigating asthma risks and other household dangers. Intervention on housing were of multiple benefit, such as adding mechanical ventilation – replacing windows to effect ventilation, temperature and humidity, which in turn will improve overall respiratory health, energy conservation and housing quality.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

Although this study has merit, it is important to indicate its shortcomings and limitations; so that when planning future work; they should be taken into consideration.

1. This health study being the first in the area was designed to investigate primarily the natural ventilation, dampness and mouldiness in the dwellings and the associated health implication of the residents. Using this study, afforded the public an opportunity to express and bring to the notice of many issues of concern, such as the environmental issues of odour, vermin, exposed drainage, etc.; although not directly related to the purpose of the survey, these concerns were forwarded to the respective departments for their attention.

2. Using instrumentation only operational on electricity also posed a limitation, in that many households were not installed with sufficient electricity supply to accommodate the use of the sampler and therefore was excluded from the survey.

3. Physical measurements of temperature and relative humidity as well as bioaerosols should be carried out on a continuous basis, for more conclusive results. This was not possible because of time and financial constraints.

4. Much of the fieldwork was conducted during the day, which was more convenient to the residents and also to minimise the invasion of privacy in their homes. Measurements taken in the evenings would have provided useful information, which would have improved understanding.

This study has found *inter alia* that :-

1. Not all dwelling units were constructed as specified in the pre-approved building plans that were provided to applicants, as there were unauthorised additions to some and amendments, incompletion and unauthorised occupation to others. Lack of control by relevant personnel was also evident.

2. The selection, use and lack of certain building material varied between the dwellings, also not conforming to the approved plans. The lack of foundation, plaster, ceilings and airbricks were factors of concern in terms of inadequate natural ventilation, dampness and mouldiness.

3. Construction workmanship, both by the owner builder, and more especially by the contractor was not of a high standard.

4. Due to the above inadequacies, the homes did not have a very "attractive appearance" visually, as lack of mortar on wall allowed for dampness and mouldiness which was easily noted.

5. Dampness (>3m^2) occurred in 51% of dwellings, and visible mould (at an average of 1 m^2) were experienced in 46% of homes. Indoor bioaerosol levels were higher than or comparable to outdoor levels. Treatment of mould growth was poor, due to ignorance, and cost constraints.

6. The predominant energy used was electricity (70%), followed by a combination of paraffin, gas and wood (1%). Their uses ranged from lighting (60%), cooking (90%) to space heating (30%).

7. The significant health outcomes associated with the lack of natural ventilation, dampness and mouldiness, were asthma, wheeze, runny nose, sinuses and dust allergy. A strong association was also noted statistically with bronchitis and chest congestion with dampness.

8. Indoor air sciences represent a truly interdisciplinary field with no separate academic curriculum. This situation is also reflected in the area of the legislation. Although there have been calls for legislation that would address the indoor environment in particular, South Africa generally does not have such specific legislation. The results of this situation is that there is generally no one profession or authority that has full

responsibility for IAQ. The same applies at government level, where a number of ministries are concerned in one way or the other with issues related to indoor environment.

With reference to the above listed findings, the following measures are recommended :-

1. Construction of dwelling structure should be closely monitored and supervised by qualified and skilful personnel, that have a thorough understanding of building construction and related regulatory requirements. With the use of appropriate expertise and improved workmanship, the dwelling will be healthy.

2. The construction of foundations, avoid the occurrence of raising damp and "springs" from emerging within the home. Rising damp, due to foundation defects and siting of the building, require effective steps to minimise dampness. In the floor or foundation with dampness problems, installation of polyethylene sheets during newly constructed buildings or renovation may prevent humidity from the ground. On the floor, some occupants may install carpets and care must be taken when selecting them.

3. Sometimes renovation of a building is more expensive than building new ones, but in the case of the house already built, the areas of mould growth should be removed and replaced with materials that will minimise condensation. Structural materials, such as plaster, mortar and wood, which are affected by sustained mould growth, should be physically removed.

4. During the total renovation or improvement of the building, proper ventilation mechanisms, such as , air bricks and additional windows must be installed to aid in removing the indoor moisture and allowing for cross ventilation. The provision of natural ventilation is one of the simplest ways of reducing condensation. Installation and the increase of the number of airbricks in the most affected areas is less expensive in terms of maintenance, but should be cleaned as regularly as possible to avoid the accumulation of dust.

5. Humidity is a problem in the areas with rainwater or the ingress of water. For effective remediation a plan to prevent future leaks or dampness that may cause colonization by mould is essential. The installation of a proper drainage system beneath the problematic areas can minimise dampness.

6. As a mechanism to create an awareness to the residents of the negative impact of inadequate natural ventilation, dampness, mouldiness, appropriate treatment, control practices, the media, labels of products and continued research should help in education and knowledge transfer.

7. The cost of the supply of electricity and electrical appliances should be made more affordable, so the electricity can be the only energy fuel used. This will decrease the sources of pollution emanating from biomass fuels and other flammable substances.

The trade, especially the building industry, needs to integrate the concept of humans and their living structures as part of the global environment, rather than being distinct from it. Remedial interventions and monitoring should be intended to help educate housing administrators about energy efficiency and health buildings in the mass provision of houses to the people of the country. Attention should be given to fostering school-based voluntary initiatives. Generally, there is widespread concern and support regarding children's health, and school-based efforts can provide considerable leverage for influencing public opinion and achieving momentum.

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APPENDIX 1

INCWADI YOLWAZI KULABO ABABAMBE IQHAZA

Sakhamuzi

Okokuqala ngizfisa ukuzazisa. Ngingu AJAY GANSAN, umfundi eNyuvesi yase Natal; – esikoleni sobudokotela, owenza izifundo zezempilo, izindlu nobunjalo bomoya esiwu phefumulayo. Kubalulekile ukuba umoya osezindlini zethu ube sezingeni elamukelekile ukuze ungabi nomthelela kwezinye izinkinga zempilo.

Indlu yakho ikhethwe kanye nezinye zabangu 414 ezizobambe iqhaza kulolucwaningo. Inani lezindlu ezikethiwe lizomelela zonke izindlu ezikhona eWaterloo Housing Development. Ngizohlola ngamehlo izindlu zenu ngiphinde ngicele ukuba niphendule imibuzo ethile mayelana nokuhlala kwenu kanjalo nezindlu. Amasampula omoya kanye nawamazinga okushisa ayothathwa ukuqoqa ulwazi. Lesifundo, ngokuxhomana nomphakathi wase Waterloo; siyokwazisa ngobungozi okungenzeka kube nibhekene nabo mayelana nobunjalo bomoya nesakhiwo sezindlu. Lolucwaningo luhlose ukuthola izindlela ezingasetshenziswa nguhulumeni ukuphucula isimo.

Qaphela ukuba noma iyiphi imininingwane oyoyinikezela iyokuba imfihlo nolwazi oluqoqiwe luyosetshenziselwa lolucwaningo kuphela.
Siza ngokuphendula yonke imibuzo, kodwa wazi ukuthi unelungelo lokunqaba ukubamba iqhaza noma ukuyeka noma nini ngaphandle kokuhlukumezeka.

Ngiyabonga
AJAY GANSAN

Ngiyavuma ukubamba iqhaza kulolucwaningo.

.. SIGNATURE / SAYINA

FULL NAME /IGAMALIGCWELE : ....

HOUSE NO / INAMBA YENDLU: ....PHASE / ISIGCEME : ....

ADDRESS / IKHELI : ....

QUESTIONNAIRE ADMINISTRATOR /
UMUNTU OBUZAYO : ....

QUESTIONNAIRE REFERENCE NUMBER : ....

APPENDIX 2
QUESTIONNAIRE

TO ASSESS THE VENTILATION EFFICIENCY, DAMPNESS AND MOULDINESS IN DWELLINGS IN THE WATERLOO HOUSING DEVELOPMENT AND ITS INFLUENCE ON HEALTH.

HOUSE NO. / ADDRESS : ______________________________

NAME : ______________________________

DATE : ______________________________

DEMOGRAPHICS :

NO. OF MEMBERS IN YOUR FAMILY [ ] _____ **MALE** _____ **FEMALE**

HOW MANY CHILDREN *(UNDER THE AGE OF 10)* IN YOUR FAMILY : _____

DO YOU HAVE ANY PETS ? *(SPECIFY NO. AND TYPE)* : ______________

ARE THERE ANY INDOOR PLANTS IN THE BUILDING : ______________

BUILDING AND APPEARANCE :

TYPE OF BUILDING CONSTRUCTION :

BRICK	WOOD	IRON	CARDBOARD	ASBESTOS

OWNER BUILT : [ ] **CONTRACTOR BUILT :** [ ]

AGE OF BUILDING : _____ **APPROXIMATE SIZE OF BUILDING :** _____

HOW MANY ROOMS ARE THERE IN YOUR HOME : [ ]

FLOOR COVERING

NONE/SAND	VINYL	CEMENT	CARPET	TILES

WALL COVERING

NONE	PLASTER	PAINTED	OTHER : __________

CEILING COVERING :

NONE	METAL	RHINOBOARD	WOOD

VENTILATION :

	WINDOWS		DOORS		AIRBRICKS

APPROXIMATE AREA OF ROOM : ....M X ....M [ ] **M^2**

DAMPNESS / MOULDINESS EVALUATION

ARE THERE SOURCES OF DAMPNESS : ☐ **YES** ☐ **NO**

DESCRIPTION OF THE CAUSE OF DAMPNESS : ______________________

AREAS WHERE THE DAMPNESS IS OCCURRING :

WALL	FLOOR	CEILING	OTHER :

DESCRIBE THE SURFACE MATERIAL THAT'S AFFECTED : ____________

DOES VISIBLE MOULD CONTAMINATION EXISTS :

0%	1-20%	21-40%	41-60%	61-80%	>80%

HOW LONG HAS MOULD BEEN PRESENT IN THESE AREAS :

<1 YEAR	1 YEAR	2 YEARS	3 YEARS	4 YEARS	5 YEARS	>5 YEARS

ARE YOU AWARE OF THE MOULD CONDITIONS IN YOUR HOME : _____

HOW DO YOU TREAT MOULDY AREAS :

CHEMICAL	WATER	PAINT

HOW LONG DOES IT TAKE TO REAPPEAR :

<1 MTH	2 MTH	3 MTH	4 MTH	5 MTH	6 MTH	> 7 MTH

SANITATION

TYPE OF SANITARY CONVENIENCE : ____________________________

LOCATION : ☐ **INDOORS** ☐ **OUTDOORS**

APPROXIMATE DISTANCE *(IF APPLICABLE)* : ______________________

REFUSE

TYPE OF REFUSE DISPOSAL USED : ______________________________

WHAT IS THE DISTANCE BETWEEN YOUR HOME AND THE NEAREST DUMPING SITE : ______________________________________

***WATER SUPPLY* :** ____

COOKING :

DO YOU COOK INDOORS : YES ☐ NO ☐

WHAT TYPE OF ENERGY DO YOU USE FOR COOKING :

PARAFFIN	GAS	ELECTRICITY	WOOD

HOW DO YOU HEAT YOUR HOME DURING WINTER : ____________

HEALTH

HOW MANY PEOPLE SHARE HIS/HER ROOM AT NIGHT : ____________

DOES ANY PERSON/S SMOKE : INDOORS OUTDOORS

WHEN DID HE / SHE START SMOKING : ____________

DOES HE / SHE NOTICE ANY ILL-EFFECTS FROM SMOKING : ____________

DOES ANY OCCUPANT SUFFER / DISPLAY ANY OF THE FOLLOWING SYMPTOMS / AILMENTS :

✔	AILMENT	DETAILS
	COUGH	
	ASTHMA	
	WHEEZING	
	BRONCHITIS	
	RUNNY NOSE	
	ITCHY EYES	
	IRRITABLE THROAT	
	EAR INFECTIONS	
	MOUTH AILMENTS	
	CHEST CONGESTION	
	SKIN RASHES	
	SINUSES	
	FLUE LIKE SYMPTOMS	
	OTHER :	
	ALLERGIES	
	HAY FEVER	
	ECZEMA	
	FOOD (food, nuts, etc)	
	DUST / MITE	
	ANIMAL DANDER	
	METALS	
	OTHER :	

PRESENT MEDICATION *(IF ANY) :* ____________

TEMPERATURE : ☐ **INDOORS** ☐ **OUTDOORS**

DO YOU NOTICE ANY OF THESE INDOOR ENVIRONMENT CONDITIONS :

INDOOR ENVIRONMENT CONDITION	***YES***	***NO***	***SOMETIMES***
TEMPERATURE			
HUMIDITY			
ODOURS			
DRAFTS			
STAGNANT AIR			
OTHER *(SPECIFY)*			

APPENDIX 3

DG 18 % (MEDIA)

Glucose	**10.0 g**
Peptone	**5.0 g**
KH_2PO_4	**1.0 g**
$MgSO_4.7H_2O$	**0.5 g**
Chloramphenicol	**0.1 g**
Dichloran (0.2 % in ethanol)	**1.0 g**
Agar	**15.0 g**

Steaming to dissolve agar, add 229 g of glycerol (analytical reagent grade), then sterilise by autoclaving. Final pH 5.6, a_w 0.955. Add up to 1000 ml of water.

APPENDIX 4a

<u>HEALTHY BUILDINGS RESEARCH</u>

DEAR RESIDENT / PARTICIPANT
WATERLOO HOUSING DEVELOPMENT

This notice is two fold, firstly; to convey our heartfelt thanks and appreciation to you for allowing us to undertake the study in your premises and secondly, to briefly inform you on the findings. A detailed report of the study will be forwarded to the Development committee, Housing Department, North Operational Entity and the Councilor.

During the months of May to July 2002, a <u>HEALTHY BUILDING RESEARCH</u> was carried out in your area. In summary, the study included visual inspections and filling of questionnaires to about 500 homes, which was assisted by a few community members. Information on the buildings and its structure, the occupants and their health and general environmental matters was gathered. Together with the questionnaires, air samples, temperature and relative humidity readings were taken.

The survey indicated, complaints of flies / ants / cockroaches and snails (32 %), and the constant experience of noxious odors (35 %) emanating from the sewer works. These conditions did not favor healthy living.
We have noticed that 47 % of the homes that were investigated were one-room dwellings, housing up to 11 occupants, which raises concern, in terms of congestion. It would be desirable to accommodate fewer people in a one-room dwelling. The age of the dwellings ranged from 1 to 6 years, having an average of 3 years. Most homes (51%) used vinyls as their floor covering, whereas 31 % had none. The most common roof was of asbestos, with 93 % of the buildings not having ceiling.

With regards to ventilation, 53 % of the houses had no airbricks and inadequate ventilation, which is in none compliance to the National Building Regulations. With the additions of airbricks and windows, ventilation will be improved. Dampness was experienced in 249 Homes (52 %), and moldiness on the walls and floors were visible predominantly. The causes of the dampness and moldiness may be attributed to inadequate ventilation, the building designs, and choice of materials and poor workmanship. There were no forms of treatment to the 48 % of the homes with moulds, whereas the remaining used water, chemical and paint. Most of the residents (70 %) used electricity as their main source of energy, and 21 % used a combination of wood, gas, paraffin and electricity, which was because of economic reasons. The residents expressed concern about certain health issues mainly related to the respiratory tract as, cough (25 %), Asthma (27 %), Chest infection (23 %), Sinuses (25 %), and Flue (23 %) were recorded. Other important observations were Tuberculosis (32 cases), and Arthritis / rheumatism (7 %). Air samples showed that there were high mould counts which has to be reduced.

Once again, thank your for your co-operation and interest shown in the Healthy Buildings research.
RESEARCHER: <u>*AJAY GANSAN*</u>

APPENDIX 4b
UCWANINGO NGEMPILO YEZINDLU

Sakhamuzi

Lesisaziso sikabili okokuqala : Ukudlulisela ukubonga kuwena ngokuvumela lolucwaningo lwenzeke emizini yenu. Okwesibili : Ukwazisa kafushane ngemiphumela ephelele eyothunyelwa ekomitini lezentuthuko, umnyango wezindlu, nomkhandlu osenyakatho kanye nekhansela lendawo.

Ngenyanga ka meyi kuya kuJuly 2002 ucwaningo ngempilo lwezezindlu lwenziwa kulendawo. Kafishane ucwaningo lwalubandakanya ukuhlela ngezipopolo nokuphendulwa kwemibuzo yezindlu ezibalelwa ku 500 namalungu ambalwa omphakathi. Ulwazi ngesakhiwo sezindlu nempilo yabanikazi bazo kanye nezemvelo kwakuhlanganisiwe kulolucwaningo.

Ucwaningo lukhombise izikhalazo, ngezimpukane, izintuthwane, amakokoloshe kanye neminenke kuwo 32 % izinga lephunga liwu 35 % elisuka esintamkokweni lokhu okungahambisani nezempilo. Esikutholile ukuthi u(47 %) wezindlu zingamakamelo ngalinye ibe indlu inabahlali abangaphezulu kuka 11 lokho okudala ukucinana. Okungaba ngconouma indlu leyo eyikamelo ihlala abantu abayingcosana. Iminyaka yezakhiwo isukela kunyaka owodwa (1) kuya kwewu (6). Imizi ebalelwa ku (51 %) isebenzisa utapetu phansi kanti ewu 31 % ayimbozwe ngalutho. Imizi eminingi ifulelwe ngo asbestos ube u(93 %) ungafakiwe uCeiling.

Izindlu eziwu 53 % azinawo izitina ezivulela amoya lokhu okungahambisani neNational Building regulations. Uma kungase kunezezelwe amawindi kanye namaventilator, umoya ungatholakala ngendlela, umswakamo owatholakala ezindlini eziwu 249 waba u(52 %). Isikutha ezindongeni naphansi kuyinto ebonakalayo. Imbangela yomswakama nesikhutha kubonakala kuwukungangeni komoya owanele, nempahla yokwakha engekho esimeni, ulwazi olungekho kubakhi.

Ayikho indlela yokuganda umswakama emizini ebalelwa ku(48 %) ekubeni, kweminye imizi basebenzisa amanzi nopende ukunqanda umswakamo. Abahlali ababalelwa ku 70 % basebenzisa ugesi, bese kuthi u 21 % usebenzisa inhlanganisela yezinkuni, igesi, uphalafini kanye nawo ugesi loku okuyimbangela yesimo somnotho. Abahlali bazwakalisa unukhathazeka ngezinye izimo zezempilo, njengesimo somgudu wokuphefumula iAsthma ewu (27%), ukukhwehlela okuwu (25%), ukucinana kwamakhala okuwu (25%), izinicinga zezilonda esifubeni nomkhuhlane. Okunye okwaqapheleka iTB eneziguli (eziwu – 32), ne Arthritis /neRheumatism (ewu 7%). Ukuhlolwa komoya ngaphandle kukhombisa isikhutha esikhulu. Noma amazinga esikhutha ephezulu umkhombandlela wezizwe zonke uthi amazinga fanele ehliswe.

Ngiyaphinda ngibonga kakhulu ngokulekelela nogqozi enilukhombisile ophenyweni lwezindlu lezempilo.