

ILLNESS, WITH PARTICULAR FOCUS ON SCHISTOSOMIASIS, ASSOCIATED WITH
RECREATIONAL USE OF WATER BY CANOEISTS IN THE MSUNDUZI, MNGENI
RIVERS IN KWAZULU-NATAL: ISSUES AND ASSOCIATED IMPLICATIONS FOR
OTHER WATER USERS.

By

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ABSTRACT

Water-related disease is a problem faced by many communities in the Mngeni and Msunduzi River valleys, both those living in a rural setting, and those within the city bounds. Treatment and management of water-related diseases such as Schistosomiasis and Hepatitis are, however, overshadowed by the priority management of more serious illnesses such as HIV/AIDS, and are therefore at risk of spreading unchecked. These diseases, while not often fatal, have a high morbidity and place unnecessary burden on communities and individuals that could otherwise make a positive contribution to the social and economic structure of the country. The impacts of water-related disease are felt by all water-users, including those recreational users such as fishermen, swimmers and canoeists.

Following a discussion of the issues and impacts of water-related disease at both a global and local scale, the research formulated a survey of the impact of water-related disease on canoeists training and racing on the Mngeni and Msunduzi Rivers as a starting point in determining the impacts on all communities using the resource. The methods employed were twofold, a *Schistosoma haematobium* infection- survey was conducted using urine samples; and a questionnaire-type survey of participants in the 2006 Dusi Canoe Marathon was conducted.

The results of the Schistosomiasis survey revealed that 4.07% (20/491) of the respondents were positive in this survey. Analysis of the questionnaire filled in by all participants further revealed that 73% of respondents tested positive for Schistosomiasis infection at some point in their canoeing career.

The post Dusi Marathon questionnaire survey was answered by 941 (54%) participants. A total of 588 (63%) reported experiencing illness as a result of taking part in the 2006 event. A further 362 individuals reported having experienced water-related illness on previous Dusi Marathons, indicating that 77% of the respondents have been ill on the Dusi in this and previous years' events. In addition, water quality samples were taken during the race and were shown to be significantly higher than the guidelines for safe recreational use of

water resources. The results also showed a radical overnight change in the *E.coli* levels following a heavy rain event on the evening before the start of the race.

The research revealed that there is a serious problem of water contamination and resultant spread of disease among canoeists using the rivers for recreational and professional sport. Contamination resulting from failure of sewage processing facilities during high rainfall events and industrial discharge into the river system results in excessive and unacceptable levels of *E.coli* and other water-related pathogens that are a severe health risk not only to canoeists but to all communities utilising this water resource.

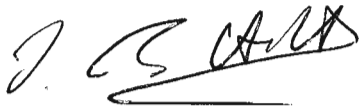
PREFACE

The research described in this mini-dissertation was carried out at the Centre for Environment, Agriculture and Development, University of KwaZulu-Natal, Pietermaritzburg, under the supervision of Trevor Hill.

This mini-dissertation represents the original work of the author and has not otherwise been submitted in any form for any degree or diploma at any university. Where use has been made of the work of others it is duly acknowledged in the text.



Signed: Kirsten Oliver



Signed: Supervisor: Trevor Hill

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LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|----------------|--|
| CMA | Catchment Management Agency |
| CSA | Canoeing South Africa |
| DUCT | Duzi-Umgeni Conservation Trust |
| DWAF | Department of Water Affairs and Forestry |
| <i>E. coli</i> | <i>Escherichia coli</i> |
| EPA | Environmental Protection Agency |
| GCIS | Government Communication and Information System |
| KNCU | KwaZulu-Natal Canoe Union |
| MDG | Millennium Development Goal |
| RHP | River Health Programme |
| SASC | South African Sports Council |
| UN | United Nations Children's Fund |
| UNESCO | United Nations Educational, Scientific and Cultural Organisation |
| UNICEF | United Nations |
| UW | Umgeni Water |
| WHO | World Health Organisation |
| WRC | Water Research Commission |
| WEHAB | Water, Energy, Health, Agriculture and Biodiversity |
| WWDR | World Water Development Report |
| WWSD | World Summit on Sustainable Development |

CHAPTER ONE

INTRODUCTION

The title of an article from a prominent South African daily newspaper (Comins, 2004) reads, "It's risky to swim in KZN Rivers". The article appeared shortly before a major annual canoeing event – The Dusi Canoe Marathon, which takes place between Pietermaritzburg and Durban, KwaZulu-Natal, South Africa – and highlighted the dangers posed to participants of the threat of contracting diseases such as Schistosomiasis (Bilharzia) and diarrhoea from the river's contaminated waters.

The Dusi Canoe Marathon hosts as many as 2000 participants, including some international competitors (GCIS, 2005) with more than five times as many spectators and supporters. Sponsorship of the race has grown to make it the richest canoeing event in the world in terms of financial input and prize-money awarded. The monetary value of the event from a marketing standpoint, for the cities of both Pietermaritzburg and Durban, and business in the surrounding areas, is approximately R100 million (WRC, 2002). Negative elements such as polluted water and potential ill health of participants could be detrimental to the race itself, and bring bad publicity to the hosting cities. On the eve of such a popular event, it is obvious why such a newspaper article might catch the attention of policy-makers and officials, as well as the general public.

But what of the rest of the year in the Msunduzi and Mngeni River Valleys? When there are no canoes making their way through the hyacinth-clogged channels, is the quality of water less of a consideration? Are the communities living on the banks of the river less at risk of infection and ill health? Their plight is certainly not less important. The reality of the valley through which these rivers flow is that most of the communities living in the vicinity of the river use the water for drinking, washing, bathing and other domestic use, often including irrigation of small vegetable gardens. These communities are at risk of contracting water-related diseases and infections all-year round.

1.1 Water health: a global human responsibility

As humans we have the greatest control of any species over the environment in which we live. If we want water in one place we simply move it there, if we want to remove waste

from our elaborate lifestyles, we throw it in the rivers and nature will duly wash away our problems. We have the world's freshwater resources at our fingertips, and it is a given right that we will have free access to those resources forever. This, at least, is the ideology perceived by millions of individuals and politicians across the globe. The reality, however, paints a distinctly different picture.

Freshwater systems are systems that incorporate a number of inter-related factors that ensure the balance and working relationship of the whole. The breakdown of one section causes a reactive dysfunction of other parts, and an overall degradation of the products and services provided by the system. With loss of habitats and diversity of flora and fauna, water resources lose their capacity to replenish themselves and recover from contamination. Failing water ecosystems and altered riverine environments provide ample opportunity for the infestation of water-related diseases, loss of safe drinking water and instability of riverbanks exacerbating flooding (Davies and Day, 1998).

The human impact on global freshwater ecosystems is severely damaging and if it continues unchecked, certain services that sustain human life will be lost (Chivian, 2002). Services such as the provision of clean, safe drinking water, sanitation and places for recreational peace of mind, all of which enhance quality of life, rely on the healthy functioning of freshwater resources (Allan and Flecker, 1993). In addition, the economic value of protecting freshwater resources is becoming more apparent in light of the many costly hazards and problems that arise partly as a consequence of mismanagement of the environment (Antrobus and Law, 2005). The remediation of damaged systems, and the sustainable management of freshwater environments into the future, will require the efforts of all water users and policy makers. Scientific understanding of the intricate dynamics of ecosystem requirements needs to be incorporated into design of institutional structures and legislation (Jansson et. al., 1999). The problem of water-related disease will need to be addressed alongside issues of water management, using this multi-disciplined, integrated approach, incorporating the cooperation and input from both governing organisations and stake-holders (Dent, 2004).

1.2 Water-related Disease: A global concern

The spread of water-related diseases affecting human health is an escalating problem faced alongside the major global concerns of managing water supply to meet the ever-growing demand whilst ensuring the least amount of environmental degradation for current and future generations. Water-related infections account for up to 80% of all infectious diseases worldwide (Pimental et. al., 1998), with as many as 90% of cases being in developing countries.

Driving forces behind the increase of water-related diseases include the changing patterns of water-use, population growth and migration, military conflict and natural disasters, changing human behaviour and advances in medicine, agriculture, industry and technology. Many of the latter advances in human activities have led to anthropogenically-induced changes in climate and the environment, exacerbating the natural fluctuations and causing extremes in climatic events and phenomena. Progress in medical technology and industry have led to the introduction of new antibiotics which are used in both humans and animals (Cotruvo et al, 2004), resulting in changing patterns of pathogen resistance to medications and mutation of known disease strains. As a consequence, the challenges of providing safe and sufficient water are no longer limited to the simple mechanics of getting water to the people, but require integrated understanding of all the contributing factors and the incorporation of skills and knowledge from a range of different fields, including the environmental, medical, social and cultural sciences, and technology and engineering.

1.3 Project Problem Statement

Addressing the United Nations Framework Convention on Climate Change, at a conference in the Argentine capital Buenos Aires, in December 2004, South African Minister of the Environment - Marthinus van Schalkwyk - raised the concern that climate and environmental change will have a severe impact on all South Africans. He stressed the already noticeable dramatic increase in water-related disease, which, with the increasing numbers of people moving to cities, and dwelling in substandard housing with poor or absent sanitation services, is only likely to get worse. The minister's concerns are further emphasised by a look at the State of the Environment Report for South Africa (Walmsley et. al., 1999), which recognises that the high level of pollution and misuse of

our rivers, as well as damming, and extraction of water has resulted in a situation where many of our rivers are degraded to a point where rehabilitation will require an enormous effort and the cooperation of all sectors of society. These two concerns – water-related disease, and the degradation of rivers – are intricately linked and cannot be considered in isolation, especially in South Africa, where the demand for safe drinking water is rapidly increasing, and the supply of freshwater resources is finite.

Compared to the rest of the world, South Africa receives an annual rainfall that is less than the global average of 1 860mm per year (Hartnady, 2003; GCIS, 2005). In addition, South Africa has relatively few free standing natural water bodies (lakes and pans), which store water for use throughout the year, and during dry seasons and drought. Most of our water is in our rivers (Davies and Day, 1998), which flow to the sea and deposit the life-giving substance into the oceans. Increasing demands on these water resources from expanding populations, advancing agriculture and industry place undue pressure on water authorities to find new and innovative management strategies for water use and extraction. Furthermore, an analysis of the distribution of water stores, and of precipitation relative to the density of human settlements will reveal that these factors are not congruent in South Africa - areas of high population density are not necessarily areas with suitable rainfall or extensive water reserves (GCIS, 2005; Turton, 1999). As a result, South Africa's rivers – as with many others worldwide – are subject to widespread damming, canalising and systems of stream diversion such as inter-basin transfers in order to ensure the provision of water to areas that cannot meet their supply requirements. In addition to this attempt to alter and catch the flow of water, South Africa - as a developing country - is subject to all of the abovementioned factors that contribute towards the degeneration of water quality and the spread of water-related disease.

1.3.1 Canoeists and the Msunduzi and Mngeni River Catchment

In a relatively small catchment such as the Msunduzi, which passes through the highly developed city of Pietermaritzburg and feeds the system of dams that provide drinking water for more than half the province's population, the problem of maintaining good water quality is of paramount importance. The costs involved in purifying highly contaminated water to make it fit for human consumption, as well as medical and man-hour costs related to diseases within the population, are enormous. Despite this, river

users continue to make use of the resource, and continue to be plagued by ill health. One such group of users is the canoeists that train and race on the Msunduzi and Mngeni in and around Pietermaritzburg and Durban.

Apart from the annual Dusi Canoe Marathon, the sport of canoeing is a prominent aspect of the Msunduzi and Mngeni rivers. In the 2005-2006 racing season a total of 41 official events, equating to 49 days on the water, were held on a variety of sections covering the length of these two rivers (KNCU, 2005). Having access to sections of the river not normally seen by the general public, and an intimate relationship with the water levels and quality, canoeists could play an important part in the assessment and monitoring of river ecosystem health and water quality. In addition, they are generally in an income and social bracket that is inclined to hold more in-depth medical records, a greater understanding of water issues, and have more influence than other river users, which means they are potentially valuable as a source of ongoing monitoring and management.

1.3.2 Water-related disease and Schistosomiasis among canoeists

Canoeists who race and train on the Mngeni and Msunduzi Rivers have been afflicted with diseases and infection associated with the river throughout the history of the sport in the area from the 1950's to current. Water-related diseases are so prevalent that the threat of contracting an illness outweighs many of the other hazards associated with racing in rivers such as rapids and snakebites (Mars and Foreman, 2000). In 2006 the problem of water-related disease was brought to the fore during the annual Dusi Canoe Marathon. During and immediately after the event, there were a worrying number of reported illnesses related to poor water quality amongst competitors (Dusi Canoe Marathon Organising Committee, 2006).

This dissertation, in response to the afore-mentioned concerns, considers the issues surrounding water health and resource management as essential elements in the reduction of water-related disease on a global scale. The research forms a backdrop for a study in the Mngeni and Msunduzi Rivers in KwaZulu-Natal, South Africa, which investigates the incidence of water-related disease and Schistosomiasis among active canoeists who use the rivers for recreational and professional sport. It is hoped that the results of this dissertation will provide an indication of the potential impacts and infection rates of other communities that use the rivers.

1.4 Aims and Objectives

1.4.1 Aim:

To explore the nature and extent of the issues surrounding river health and water-related disease in the Msunduzi and Mngeni River Catchments, and how they relate to human health, with particular focus on the impact on canoeists.

1.4.2 Objectives:

1. To review available literature on water-related disease issues, their impact on human health and how they are related to and affected by river and ecosystem health, and human interaction with water resources, on both a global and local scale.
2. To assess the effectiveness of management strategies and projects that have been implemented within the catchments and, to increase awareness of river health and values, to enforce compliance and to deal with catchment management issues.
3. To establish the extent to which water-related diseases affected active canoeists who took part in the 2006 Dusi Canoe Marathon and train on the Msunduzi and Mngeni River catchments, as a starting point to determining the magnitude of the problem and whether there is cause for concern.
4. To undertake a survey of incidences of Schistosomiasis among canoeists in South Africa to determine the regional variation and extent of the disease among this group of water users as an indication of potential broader infection among other water users in the same areas.
5. To provide recommendations for further research and possible strategies for improving the health of the Msunduzi and Mngeni Rivers and surrounding catchment, and decreasing the disease burden on local communities and river users.

CHAPTER TWO

LITERATURE REVIEW

This chapter is a review of available literature on the processes and concepts surrounding river health and water-related diseases. Figure 2.1 illustrates the conceptual framework and the relationships between factors contributing to this research. Water-related diseases and their associated pathogens and implications are discussed at a global scale, and the chapter closes with a review of these integrated issues within the setting of the Msunduzi/Mngeni Rivers and the sport of canoeing.

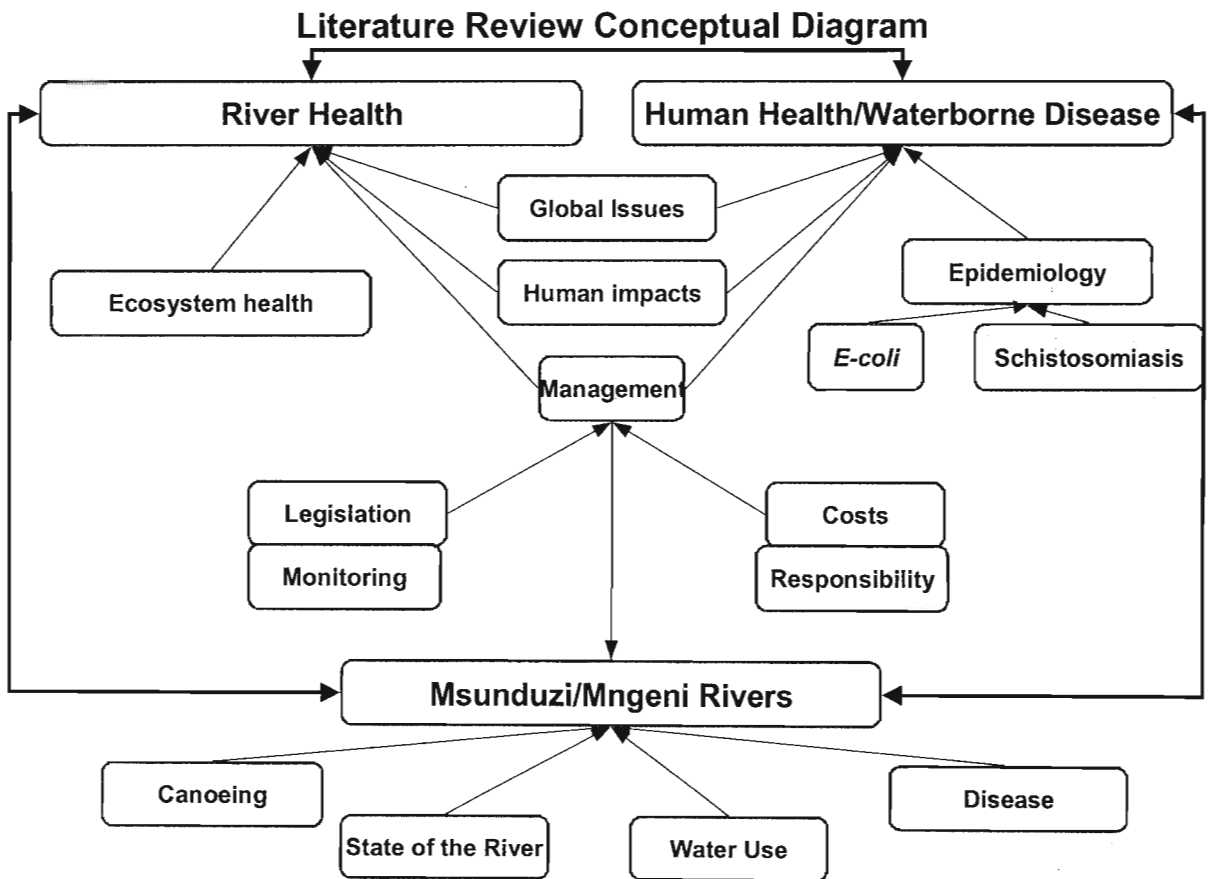


Figure 2.1 Conceptual framework for literature review

2.1 River Health and ecosystem management

A river system is composed of an interconnected web of components and processes. Apart from the hydrological processes of water circulation and distribution, the fluvial system relies heavily on the geomorphological processes of sedimentation and erosion in the creation and dynamics of natural habitats (Leuven and Poudevigne, 2002), the chemistry of water, and the fluctuations in water temperature (Naiman et. al, 2000). A negative disturbance in one area of the system has a compound effect on other parts, which in turn results in a breakdown of the web (McNally and Tognetti, 2002). The results of such a breakdown in the system may be clearly and immediately obvious - such as the death of fish poisoned by polluted water - or less obvious such as increased sedimentation through the loss of fertile topsoil as a result of poor farming practices, which leads to unstable river banks and loss of riverine habitats. In order to fully assess the health of a river, it needs to be understood as an integrated entity composed of many parts that all contribute to the healthy functioning of the whole.

One of the major paradigm shifts in the idea of water resource management is based on the understanding that water resources are integrated with their surroundings and are a small part of a much larger picture. As Gregory et. al. (1991) pointed out, the riverine zone provides an interface where the aquatic and the terrestrial ecosystems interact. There is no distinctive edge, the two merge onto one another and the activities of the one rely and impact on the activities of the other. Similarly, the activities of man within the terrestrial and riparian zones will have an impact on both terrestrial and aquatic ecosystems, and need to be considered in the management of those resources to ensure they inflict the least amount of damage. In the past the management of water resources has been seen in a purely anthropogenic light, where the political and engineering objectives of society disregarded the fact that water is a finite resource is being detrimentally affected by our use of it (Karr and Chu, 2000).

The concept of river health is often defined by the stakeholder describing it (for example a fisherman considers a river with good fish stocks to be healthy), and is therefore determined by the particular service required (Boulton, 1999; Karr, 1999). This bias, while seemingly anthropogenically selfish, highlights the importance humans' place on river

systems for the goods and services they provide. Primary goods and services provided by healthy river systems are outlined in Table 2.1.

Table 2.1 Examples of Goods and Services provided by healthy rivers (Meyer, 1997)

| Goods | Services |
|---|---|
| <ul style="list-style-type: none"> - Clean water for drinking, washing, and other uses - Adequate supply of water for irrigation and industry - Uncontaminated foods (e.g. fish, crayfish, shellfish) - Challenging waterways for kayaking - Sites for swimming - An environment for contemplation and spiritual renewal - Unique species to observe | <ul style="list-style-type: none"> - Cleansing and detoxifying water - Producing fish for angling - Reducing sediment inputs to coastal zone - Providing aesthetic pleasures - Maintaining water supply - Decomposing organic matter - Storing and regenerating essential elements |

It is increasingly obvious, however, that misuse and overuse of rivers is not only detrimental to the systems themselves, but jeopardises the essential ability of those ecosystems to continue to provide the services and needs on which humans depend. In addition, as discussed by Meyer (1997), there is increasing argument for the intrinsic value of ecosystems, in which system health and integrity have value beyond that of human needs. Unfortunately, however, this view is not widely supported in the face of increasing poverty, water shortages and other human problems, and conservationists and water ecologists continue to be compelled to sell the idea of the protection of water resources for the economic and social benefits they provide to humanity.

With this in mind, much consideration is given to the reasons why there are so many problems associated with meeting the human demand for fresh water. The general consensus indicates that it is not as a result of a shortage of freshwater on the planet that global water problems arise. There is enough water available, the problem is rather that water is unevenly distributed across the globe, increasingly under pressure from demand, and seriously polluted as a result of human mismanagement of resources and activities that are detrimental to water quality (Falkenmark et. al., 1999; WEHAB Working Group, 2002; UN/WWAP, 2006).

2.1.1 Impacts of human activities on freshwater ecosystems

Of all the water on earth, less than three percent is available as freshwater for drinking and irrigation of crops, and as much as two thirds of this available three percent is locked in glaciers and ice-caps (Jackson et. al., 2001). The remaining thirty-one percent, which constitutes the hydrological cycle and exists in lakes, rivers, aquifers, plants and the atmosphere, is shared by all life forms. In some places on earth, humans are already utilising more than half of this tiny proportion (Postel, 2002).

There are three main uses of freshwater resources by humans – irrigation, industrial and commercial activities, and domestic or residential use. Human activities that impact on rivers and natural freshwater resources are arranged in Table 2.2. In order to supply enough for these activities, water is appropriated, or controlled, in three primary ways – i) renewable requisition, ii) consumed and iii) as an instream resource (Jackson et. al., 2001). Renewable water resources are those that flow through the hydrological cycle - are absorbed into the atmosphere by heat from the sun, precipitated to earth and flow into rivers, lakes and oceans (Postel et. al., 1996). This water is used in a reusable capacity, but reduces the quality of the water through increased concentrations of ions, nutrients and contaminants. This appropriation may require further treatment of water, and increases the cost of supply. Secondly, water may be utilised and consumed, as occurs as a result of extraction of ground water reserves and evapotranspiration from irrigation. This water is no longer available for human use and results in phenomena such as the retreat of shorelines and loss of associated human activity, decrease in available croplands and a decrease in the size of lakes and natural reservoirs. Thirdly, water is appropriated as an instream resource, where it is required for activities such as recreation, for the dilution of human waste, the protection of biodiversity, the sustenance of fisheries and the maintenance of estuaries.

Table 2.2 Impact of human activities on river systems

| ACTIVITY | IMPACT | REFERENCES |
|---|---|---|
| <p>Agriculture: Livestock grazing; cultivation; clearing, irrigation, silviculture</p> | <ul style="list-style-type: none"> - Overgrazing and trampling alters stream morphology and function - Irrigated agriculture is the greatest consumer (69%) of renewable water resources - Chemical fertilizers and nitrates leech into ground water and natural reservoirs - Removal of riparian vegetation, resulting in the destabilisation of river banks, a change in the nutrient supply, and a change in the temperature regime as a result of altered shade cover - Increased erosion and siltation of river system, dams and estuaries - Soil fertility is jeopardised through leeching and pollutants | <p>Falkenmark et. al., 1999 Postel et. al., 1996 UN/WWDR, 2006 Allan and Flecker, 1993 Naiman et. al., 2000 Jackson et. al., 2001</p> |
| <p>Population growth and Urbanisation</p> | <ul style="list-style-type: none"> - Increased pressure on freshwater supply - Increased urban population leading to increased pollution and high loads of waste and waste water as a result of low cost housing and poverty - Increased sewerage and waste resulting in organic pollution. - Development of dwellings and infrastructure in outlying areas leads to contamination of natural rivers - Heavy metals leached from waste dumps | <p>Jackson et. al., 2001 Postel et. al., 1996 Allan and Flecker, 1993</p> |
| <p>Trade, travel, tourism and recreational use of rivers: Fishing, canoeing, rafting, motor boating</p> | <ul style="list-style-type: none"> - Introduction of alien species of flora and fauna to new riverine ecosystems - Change in the chemical composition of water affecting fauna and flora - Obstruction of flow of water - Interference with oxygen levels - Alteration of biodiversity through predation and mixed gene pools - Introduction of new diseases - Demand for the development of infrastructure - Contamination of water through oils spills and litter - Introduction of alien species of fish and fishing bait to suit fishing demand | <p>Allan and Flecker, 1993 Naiman et. al., 2000 Postel et. al., 1996</p> |
| <p>Water regulation:</p> | <ul style="list-style-type: none"> - Alteration of natural patterns of flow - flood events, | <p>Falkenmark et. al.,</p> |

| | | |
|--|---|--|
| <p>Water abstraction; Hydroelectric power; instream engineering (dams, bridges, weirs and canals); Alteration of stream morphology (deepening and straightening)</p> | <p>seasonal change in high and low flow levels</p> <ul style="list-style-type: none"> - Change in sediment transportation capacity - unnatural erosion and deposition - Disturbance of the microhabitat - Inhibits migratory movement of species (E.g. Freshwater salmon and eels) - Alteration of habitat availability - Loss of biodiversity and shifts in the food chain - Dams result in loss of terrestrial fauna and flora as a result of loss of unique valley habitats | <p>1999 WCD, 2000 Allan and Flecker, 1993 Naiman et. al., 2000</p> |
| <p>Industry, infrastructure development and Mining: Roads and bridges; Industrial development; Sand mining</p> | <ul style="list-style-type: none"> - Affect fertility of soils in the floodplain - Destruction of habitat - Increase in impervious surfaces leads to increased runoff and runoff velocity - Alteration of physical structure of riverine landscape e.g. compaction of soil - Contamination of water from industrial and public waste effluent and mine drainage - Removal of natural vegetation and infestation of alien plants - Greenhouse gases from industry leading to increased climate change and associated hydrological changes | <p>Leuven and Poudevigne, 2002 Allan and Flecker, 1993 Jackson et. al., 2001</p> |

The mechanisms by which land-use influences river ecosystems is well documented in the literature (Allan, 2004), ranging through impacts such as sedimentation, nutrient enrichment, contaminant pollution, hydrologic alteration, riparian clearing/canopy opening and loss of large woody debris. Allan (2004) also discusses the variability of assessing impacts and the scale at which those impacts might occur. For example, the impact of shade on the temperature regime of a stream may occur on a highly localized scale – trees over the immediate riverbank – but cumulate over a great distance. The impacts, in turn, may have a small localized component, but are more than likely linked to a sequence of secondary impacts as the ripple effect moves through the hierarchy of the stream structure (from the microhabitat to stream riffle to segment to the stream as a whole) (Frissell et. al., 1986).

One of the methods to combat these impacts is the application of the philosophy of sustainable water use, where the needs of humans are balanced with ecological

requirements in a management strategy that accommodates for the desires and needs of future generations (Gleick, 1998, Ashton, 1999). This concept is coupled with the initiative of integrated catchment management, in which the management strategy for water resources is constructed on the understanding that all uses of the resource and all activities taking place within a given catchment contribute, either negatively to positively to its health, and that all users of the resource are responsible for ensuring its sustainability.

Integrated catchment management strategies can vary from livestock grazing management practices (Agouridis, et. al., 2005) – in which alternative options for watering and grazing cattle are considered that have less impact on actual stream channel, to tax rebates for organizations – such as forestry – that set aside areas of their land for wetland rehabilitation. The alternative method is designed as a substitute or compromise for existing strategies that continue to work for the land user, but also accommodate for the health of the catchment as a whole.

2.1.2 Value of protecting freshwater resources

There are many advantages, both economic and social, to protecting or managing freshwater resources sustainably. These range from improved crop yield and livestock health to decreased cost of purification for drinking water and aesthetic appeal, which attracts income from tourism and instils a sense of ownership and social well-being (Dunn, 2000). A cyclical ideology often associated with human/ecological interaction is that of feedback mechanisms, where activities and change result in either positive or negative returns on either the human or the ecological side. The concept is illustrated by Falkenmark et. al. (1999) in their discussion of the effects of community gardening, and clearly explains the idea of positive benefits of integrated management of freshwater resources. Figure 2.2 demonstrates how the inception of community gardening results in increased hydrological productivity as well as improvements in socio-economic standards and human life. This principle can be applied to most areas where careful consideration of the needs of both human and ecological water requirements are taken into account.

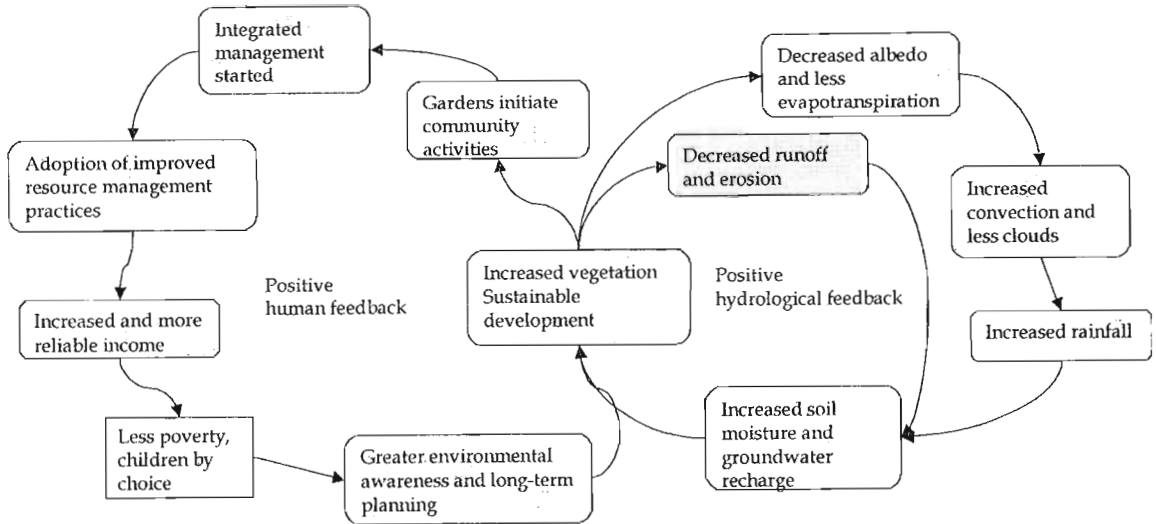


Figure 2.2 Positive feedback mechanisms from community gardening (After Falkenmark et. al., 1999)

2.1.3 Global management of water resources

Many of the problems associated with water resource management have, in the past, related to the manner in which water resources and land management were perceived as separate entities and dealt with in isolation from one another (Falkenmark et. al., 1999). In nature, as has been illustrated previously, the two are intricately linked and must be considered together if management is to be successful.

It is now understood that traditional means of appropriating more water, such as desalination of sea water, towing of ice-bergs and construction of more and larger dams are expensive and at their current rate will lead to further destruction of ecological functioning of river systems. Effective solutions to pollution and greater investment in environmentally supportive activities would result in more water being available for use (Postel et. al., 1996) for both human needs and ecological requirements now and in the future. Governments and water management agencies will need innovative, holistic strategies to prioritise demands for future use and supply.

Jackson et. al. (2001) identify some priorities for balancing the current and future demands on global freshwater supply (Table 2.3).

Table 2.3 Priorities for balancing current and future demands on global freshwater supply (Jackson et. al., 2001)

- Promotion of an “environmental water reserve” to ensure that ecosystems receive the quantity, quality and timing of flows needed to support their ecological functions and their services to society
- Legal recognition of surface and renewable ground waters as a single coupled resource
- Improved monitoring, assessment, and forecasting of water quantity and quality for allocating water resources among competing needs
- Protection of critical habitats such as groundwater recharge zones and watersheds
- A more realistic valuation of water supply and freshwater ecosystem services
- Stronger incentives for efficient water use in all sectors of the economy
- Continued improvement in eliminating point and nonpoint sources of pollution
- A well-coordinated national plan for managing the diverse and growing pressures on freshwater systems and for establishing goals and research priorities for cross-cutting water issues.

The philosophy of these priorities is that while management structures need to be formalised in legislation and that governmental involvement and overseeing is essential, so too is the consideration of all resource users needs, including the ecological requirements. Ecological requirements can be determined by establishing the ‘reserve’ of a water resource, which is the minimum amount of water required for healthy ecological functioning of the system (Republic of South Africa, 1998). This, and other strategies implied by this list of priorities, creates an integrated approach to the management of water resources that embraces all the environmental and anthropogenic factors.

As we have seen, better stewardship of water resources will not only help ensure the sustainability of those resources, but will contribute greatly to other areas of human livelihoods. This will be evident where lack of access to safe water is instrumental in the failing health of many poverty-stricken communities.

2.2 Human Health – Water-related Diseases

All organisms, including humans, rely on water as a primary necessity, without which life cannot be sustained. Apart from the provision of essential foodstuffs and life-supporting services, ecosystems and biodiversity ensure the equilibrium between species, which ultimately controls the emergence and spread of infectious diseases (Chivian, 2002).

One area where the environment is severely altered is on the urban fringe in developing countries' cities, where rapid urbanisation has resulted in the establishment of low cost, often informal residential developments that lack sufficient sanitation and water services. The poverty stricken people living in these communities rely heavily on the goods and services provided by the environment in which they live, and are less likely to have the resources available to deal with problems of disease arising from their situation. These are the people most likely to benefit from improved conditions in the environment (McNally and Tognetti, 2002). Furthermore, the cost of treatment and dealing with impoverished societies debilitates the economic prosperity and social stability of a country as a whole. Investing in the protection of existing water resources and controlling the factors that lead to their degradation in a sustainable manner, so that they continue to provide services, is an economically sound decision (SEI and UNDP, 2005). Apart from reducing the cost of disease and poverty, improvements will result in further economic returns such as improved income as a result of increased work hours and school attendance as communities move beyond the grip of perpetual water-related disease. The value of effective water resource management strategies should be recognised by all sectors of society (Lindqvist, 1998), as it impacts on all communities that exist as members of a country's economy.

The problem of impoverished societies suffering from poor sanitation and subsequent disease and squalor is a worldwide phenomenon, essentially influenced by water resource development, water management and water use (UNESCO-WWAP, 2006). In addition, all living organisms are limited in their development and growth by diseases in their environment (Pimental et. al., 1998). Thus, societies suffering from numerous water-related diseases will suffer from loss of productivity and opportunity and economic and social progress will be slow. Diseases, and disease pathogens – which are often organisms in themselves – are similarly inclined and influenced by numerous changes and conditions in their environments. This section raises and discusses the issues pertinent to water-related diseases and their impact on human health, international strategies and policies regarding the management of water resources. The diseases themselves are briefly described, focusing on those associated with recreational water-use, in line with the theme of this dissertation.

2.2.1 Changing dynamics of disease: Impacts of anthropogenic and environmental factors

The nineteenth century saw major changes and advances in sanitation, antibiotics and vaccines, and improvements in standards of living and health. Along with these improvements, however, changes in human behaviour and activities has led to increased risk factors, including geographical and environmental changes, socio-economic factors, pathogen-specific factors and those related to individual behaviour (Dangendorf, 2004), all of which provide favourable conditions for the occurrence and spread of disease. Towards the end of the twentieth century, and continuing into this century, there has been a significant increase in local and global epidemics such as diphtheria, tuberculosis, cholera and Ebola (Dangendorf, 2004), as well as the global pandemic of the Human Immune Deficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS). The increase in disease is countered to some extent by advances in human understanding of molecular biology and of how the immune system functions and fights infection (Nowak, 1999). With this understanding, and advances in medical research and technology, new medicines and vaccines are being developed to help combat disease (Dangendorf, 2004). In response, however, the organisms and pathogens that cause infection adapt, and new and more resistant disease strains emerge. The dynamics of disease, human movement and medical treatment are graphically illustrated in Figure 2.3.

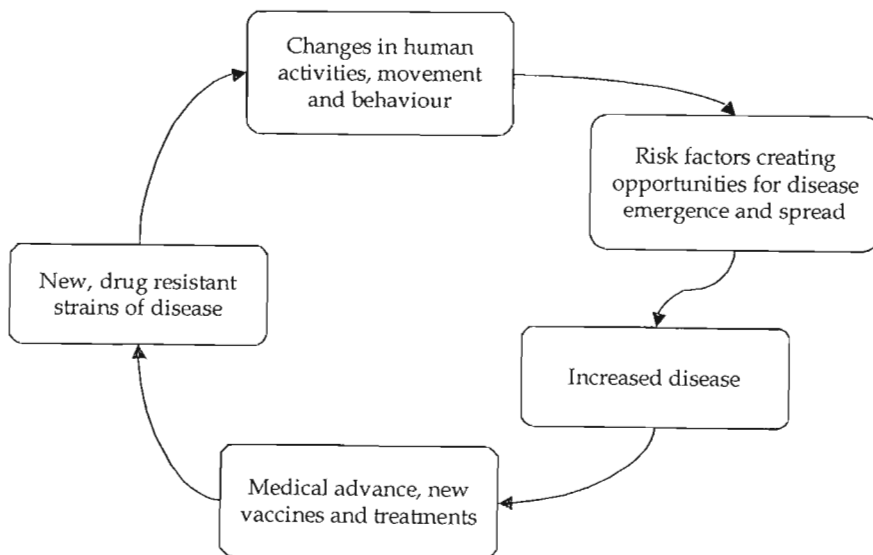


Figure 2.3 Cycle of disease dynamics in response to human activities and medical advances

The risk factors created by changes in the human environments and their impact on disease dynamics are discussed below.

2.2.1.1 Pathogen reservoirs and mobility: Human behaviour, population growth and urbanisation, conflict/wars, travel

Changes in human behaviour, their mobility and the extent of the populations provides disease pathogens with reservoirs and pathways for movement from one location to another and thus influence the rate and spatial extent of transmission (Cotruvo et al., 2004).

Increased global travel as a result of tourism, labour migration and refugees displaced by wars, military conflict and natural disasters all provide routes for the spread of disease to new areas. According to the International Organisation for Migration, in 2003 one in 35 people was a migrant (WHO, 2003a). Urbanisation accounts for a large portion of this migration, as people move from rural areas to cities in the hope of finding work, and better living conditions. In many developing countries, the influx of thousands of people to urban areas results in condensed communities that act as 'hubs' of high activity, industry and waste (Lindqvist, 1998). It is projected that by 2025 two-thirds of the world's populations will live in urban environments (Pimental et. al., 1998). As this occurs, the distribution of the increasing population will become steadily more unequal, and cities will suffer with increasing problems associated with high densities of poor people, poor quality housing, insufficient health and social services, and limited access to basic amenities such as water supply and sanitation (WHO, 2003a). Similarly, the squalor and poor sanitary conditions associated with conflict situations and natural disasters create ideal conditions for the growth of pathogen reservoirs and disease transmission (WHO, 2003a).

Movement of people to previously uninhabited areas changes the nature of the natural environment of those areas, and breaks down the boundaries between human and natural environments, often opening new pathways for dissemination of disease pathogens to human hosts (WHO, 2003a). Six hundred and ninety million tourist arrivals were recorded globally in 2001 alone (WHO, 2003a), with considerably more than previously travelling to less visited areas of Africa and other developing countries, where they

contract local diseases and return home, initiating the spread of pathogens to new areas, which have no natural predators or controls for the disease.

An often-overlooked factor in the change in human behaviour is the shift towards the use of water resources for recreation. Bathing, fishing, canoeing in rivers, streams and at beaches by both tourists and local residents increases the risk of contracting infectious water-related diseases through ingestion of water and dermal contact (WHO, 2003a). Recreational use of water is discussed in more detail in section 2.2.4.

2.2.1.2 Cross boundary importation and exportation - trade

The advent of international trade, and agricultural subsidisation has led to many areas losing their diversity in terms of plant species and land-use activities. Agricultural subsidies and cross-boundary trade allows one area to specialise in a single crop or activity and import everything else that is needed (WHO, 2003a). The cross-boundary movement of goods requires extensive surveillance for infected animals and potential invasive species, and in many areas this is not effectively carried out (Dangendorf, 2004).

2.2.1.3 Water pollution and diseases

Pollution of watercourses occurs as a result of numerous human activities. The Comprehensive Assessment of the Freshwater Resources of the World, presented to the UN General Assembly in June 1997, identified five different kinds of pollution affecting water resources, their sources and their impact on the riverine ecosystem (Lindqvist, 1998) (Table 2.4).

The most directly influential of these pollutants to water-related disease, is the dramatic increase in micro organisms as a consequence of the deposition of sewerage and household and industrial waste directly into water bodies (Pimental, et al. 1998). This water is then used for drinking, bathing and other domestic uses by communities that do not have access to improved water supply and sanitation. Disease is spread through ingestion and contact with this contaminated water.

Table 2.4 Different types of pollution, their sources and their impact on the riverine ecosystem.

(Adapted from Lindqvist, 1998)

| <u>POLLUTION TYPE</u> | <u>SOURCE</u> | <u>IMPACT</u> |
|-----------------------|--|--|
| Micro-organisms | Human and animal wastes | |
| Algae | Naturally found, but exacerbated by the presence of micro organisms and other by-products of agriculture and industry | Result in decreased oxygen in the water resource - aquatic life is suffocated |
| Nitrates | Fertilizers, and human and animal wastes | In the human body nitrates decrease the oxygen carrying capacity of haemoglobin. Detrimental to infants |
| Chemicals | From human activities, agriculture and industry - exist in over 100 000 different forms | Traces now found in humans and animals worldwide. |
| Heavy Metals | Made available through human activities, industry and agriculture - would not naturally be available in such high quantities | Some heavy metals toxic to humans, others to aquatic life. |

2.2.1.4 *Agricultural and husbandry practices*

Agricultural mismanagement results in the denudation of land and an increase in erosion and run-off into watercourses. Apart from the problem of the high silt content of rivers as a result of erosion, much of the fertile topsoil is lost, resulting in poor quality soils and the instability of riverbanks. In addition, agricultural by-products as a result of mass production of livestock and food results in the deposition and over-application of fertilisers (Dangendorf, 2004) as well as pesticides and chemicals, which are leached into water reservoirs during irrigation, rain events and increased surface runoff. Rivers and streams are altered by the polluted water and erosion, and this provides an ideal background for the incidence of helminths and microbes, which are well suited to the changed water environment (Pimental, et al. 1998).

2.2.1.5 *Water control and irrigation*

The demand for water for domestic, agricultural and industrial use has led to worldwide control of water resources. Dams are constructed to reserve water for continued use during the dry season or in times of drought, canals are built to divert water and

transport it to where it is needed and ultimately more water is removed from rivers and streams for human activities, and less is available for ecological processes. This decreased volume of water results in an increased concentration of impurities and pollutants (Lindqvist, 1998) and existing natural purification systems fail, as the assimilative capacity of the river is exceeded.

The construction of dams, resulting in large bodies of stagnant water, increases the incidence of water-based diseases, as the still water provides ideal conditions and breeding sites for certain organisms and pathogens (Dangendorf, 2004). For example, many snail species (especially Planorbidae) thrive in these areas. Snails from this family act as an intermediate host to the *Schistosoma* worm, which causes the Schistosomiasis infection in humans (Hartnady, 2003; Reich, 1998).

2.2.1.6 Pathogen characteristics – genetic mutations, drug resistance

The resistance of pathogens to drugs is increasing, providing medical scientists with new challenges in finding ways to combat the spread and treatment of disease. One of the major reasons for this is the use of the same antibiotics used in animals being used in the treatment of humans, both in situations where the treated animals then provide sustenance for humans, and where humans are in direct contact with the animals, for example pets. The result is an increased overall resistance of pathogens to antibiotics (Pimental et al., 1998). In South Africa, for example, there is evidence that resistance of the invasive *Streptococcus pneumoniae* to penicillin has increased to the extent that 95% of isolates found in hospitals and 40% of those found in communities do not respond to treatment by the drug (WHO, 1996).

2.2.1.7 Impact of climate change – seasonality, heavy rain and floods, temperature

The variety and intensity of changes in water-related disease emergence and spread as a result of climate change are still relatively unconfirmed, as scientists are still gauging the potential impacts of global warming (Haines and Patz, 2004). These changes will need to be considered, however, in the establishment of disease control measures and strategies and the institutional development of policies for water resource management at both global and local levels.

Changes in global climate have significant implications for water-related diseases. Extreme weather conditions and climatic anomalies, in which water-related pathogens and diseases thrive, are becoming more frequent, with flash floods, large and abnormal fluctuations in seasonal temperature, and increased droughts occurring globally (Epstein, 2002). High rainfall events and flash floods create ideal conditions for water-related disease as they wash additional toxins and pollutants into water resources and overwhelm water treatment facilities (Leder et. al., 2002). At the other end of the scale, water shortages as a result of droughts may lead to increased use of contaminated sources of water by poorer communities for domestic washing and drinking. Increase in global sea temperatures may lead to algal blooms, which have been found to be associated with Cholera outbreaks (Haines and Patz, 2004) and respiratory infections. Globally, shifts in temperature and climate trends result in changes in the geographical range of pathogens, vectors and their reservoirs, often extending into previously uninfected areas (Dangendorf, 2004).

2.2.2 Water and policy

The history of the development and implementation of international water policy dates back to the late 1970's, although possibly the most influential and progressive years were from 1981 to 1990, during the International Drinking Water and Sanitation Decade (IDWSSD) (UN/WWAP, 2003). During this time extensive progress was made in the supply of drinking water to previously unserved communities. There was also progress in the upgrade of sanitation infrastructure and services. The provision of sanitation has, however, lagged significantly behind the progress made in drinking water supply, as a result of hindrances such as negative attitudes to change, cultural beliefs and taboos about excreta (urine and faeces). Sanitation remains a major challenge in water and water-related disease management (UN/WWAP, 2003).

In the 1990's, poverty and over-consumption were identified as major drivers of unsustainable exploitation of water and natural resources. The Dublin Conference in 1992 identified these challenges in the Dublin Statement on Water and Sustainable Development, in which four principles emerged (Table 2.5).

Table 2.5 Dublin Statement Water Principles

| |
|---|
| Principles: |
| 1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment |
| 2. Water development and management should be based on a participatory approach, involving users, planners and policy makers at all levels. |
| 3. Women play a central part in the provision, management and safeguarding of water, and |
| 4. Water has an economic value in all its competing uses, and should be recognised as an economic good. |

These principles formed the basis for the Rio Earth Summit in the same year, and are included in chapter 18 of the Agenda 21 principles on water and sustainable development (UN/WWAP, 2003). The principles recognise many of the problems of the past with regard to global perceptions of water management – perceptions that led to societal belief that water is an infinite resource, which is expendable and exploitable and does not need to be managed. Contrary to this, the first principle recognises that water is not infinite and needs to be understood and managed by all users for the benefit of current and future generations. The principle is based on the understanding that water management requires the integration of a multitude of disciplines and resources if it is to be successful (Solanes and Gonzalez-Villarreal, 1999).

The second principle compliments the first by recognising the integration and participation of all stakeholders in the management of water resources, as opposed to limited responsibility of regional management of water resources by policy makers. At the same time, however, management does require an over-arching governmental overseer as is illustrated by policy that has been implemented in various parts of the world (Solanes and Gonzalez-Villarreal, 1999).

The responsibility that women, in many less developed countries, bear as the collectors of water from rural settings far from the homestead, and as the health-watchers of the family is highlighted in the third principle. The burden placed on women and young girls to collect water as a daily task in areas without water supply and sanitation effectively hinders their opportunities for development, as it removes young girls from the

classroom, is physically debilitating, and limits their future contribution to society. Their involvement in management strategies is invaluable and a core function of successful water policy-making (SEI and UNDP, 2005).

Finally, the recognition that water is an economic good - while previously accepted in many countries, and supported by private organisations charging for water supply (Rogers, et. al., 2000) - needs to be recognised at a policy level. The fourth Dublin Principle provides for the national and international assertion that the beneficial and effective use of water is an economic good, and should be legislated in such a way that it eliminates opportunities for the monopolisation, hoarding and waste of the resource (Solanes and Gonzalez-Villarreal, 1999).

These four principles, incorporating environmental, social, economic and political issues around water resource management provide a foundation for further global development of water principles and other global water management strategies.

In September 2000, 147 heads of state and governments, and 189 nations signed the United Nations Millennium Declaration, which included a set of time-bound, measurable goals and targets aimed at combating the global issues of poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women. In 2002, the Johannesburg World Summit on Sustainable Development, held in South Africa, amplified the goals and launched the Johannesburg Plan of Implementation, which set the following objective for water scarcity and water-related disease, as target ten under Millennium goal seven:

Target 10: To halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation.

The International Decade for Action (2005-2015) was set out on the 22 March 2005 by the UN General Assembly (WHO and UNICEF, 2005), and established the time span for implementation of the Millennium Development Goals (MDG's). While this is the only target pertaining directly to water management, Soussan (2002, SEI and UNDP, 2005), highlights how improved water management can make a significant contribution, both directly and indirectly towards achieving all of the goals (Table 2.6).

The direct contributions of water management to achieving the MDG's, listed in Table 2.6, are a reflection of the importance of water in many human needs and activities, and indicates how the need for water goes beyond survival, to factors of health, education, life expectancy, well-being and social development (WHO, 2005). The availability of water within communities directly contributes to their economic development by freeing up time, ordinarily spent by women collecting water and tending to sick family members. This time can be better spent on producing either food for the family in gardens or in production, allowing women to become economically active. Indirect contributions, such as minimising the time spent collecting water by young women, and reducing the number of school days lost due to ill-health as a contributor to primary education, is a major factor in the development of communities and the upliftment of the economy in the future, as better educated children are more likely to be successful in their future jobs.

Effective water management contributes to reducing hunger by increasing the availability of sufficient water for growing crops and watering livestock, ensuring healthy supply of food for both subsistence and commercial gains. Indirectly this is achieved as ecological health helps to maintain the quality of water. Similarly the supply of good quality water and food leads to healthier children who are less susceptible to disease. Together with food for good nutrition, MDG's four and five - decreasing mortality of both children and mothers - can be directly contributed to through the provision of sufficient water for health and cleanliness.

Water is a major contributing factor in the prevention of diseases through improving cleanliness and reducing the opportunities for the infestation of pathogens. By the same token, good water management leads to healthier environments. Water is an essential part of all ecosystems and if it is compromised, the system as a whole will suffer. On both a global and local scale, the care of water resources will help reduce the incidence and impact of natural disasters and anomalies such as flooding and climate change. The recognition that water plays such a vital role for all could lead to better inter-governmental cooperation if global leaders are dedicated to the tasks set out in these goals.

Unfortunately meeting the Millennium goals for water will require more commitment and action by national governments and international aid agencies than is currently

evident and even if these are met, 'as many as 76 million people will die by 2020 of preventable water-related diseases.' (Gleick, 2002: page 9).

Table 2.6 Water, Poverty and the Millennium Goals (Soussan, 2002)

| Millennium Goals | | How water management contributes to achieving goals | |
|---|--|--|---|
| Goal | Target | Directly contributes | Indirectly contributes |
| Goal 1: Eradicate extreme poverty and hunger: | Target 1: To halve by 2015 the proportion of the world's people whose income is less than \$1/day | <ul style="list-style-type: none"> • Water as a factor of production in homestead gardening, agriculture, industry and other types of economic activity • Investments in water infrastructure and services act as a catalyst for local and regional development • Household water treatment and safe storage reduces the disease burden among the poorest who have no access to safe drinking water | <ul style="list-style-type: none"> • Reduced vulnerability to water-related hazards reduces risks in investments and production • Reduced ecosystem degradation boosts local-level sustainable development • Improved health from better quality water increases productive capacities |
| | Target 2: To halve by 2015 the proportion of the world's people who suffer from hunger | <ul style="list-style-type: none"> • Water as a direct input into irrigation and fertilisers from wastewater and human excreta as a direct input into agric- and aquaculture for expanded food production with due regard for health aspects • Reliable water for subsistence agriculture, home gardens, livestock, tree crops • Sustainable production of fish, tree crops and other foods gathered in common property resources | <ul style="list-style-type: none"> • Ensure ecosystems integrity to maintain water flows to food production • Reduced urban hunger by cheaper food grains from more reliable water supplies |
| Goal 2: Achieve universal primary education: | Target 3: To ensure that, by 2015, children everywhere will be able to complete a full course of primary schooling | | <ul style="list-style-type: none"> • Improved school attendance from improved health and reduced water-carrying burdens, especially for girls • A safer school environment |

| | | | |
|--|--|---|--|
| | | | for girls through appropriate sanitation facilities in schools results in increased attendance |
| Goal 3: Promote gender equality and empower women: | Target 4: Progress towards gender equality and the empowerment of women should be demonstrated by ensuring that girls and boys have equal access to primary and secondary education | <ul style="list-style-type: none"> • Gender sensitive water management programmes help empower women and give them confidence to increase their role in other societal activities | <ul style="list-style-type: none"> • Community-based organisations for water management improve social capital of women • Reduced time and health burdens from improved water services lead to more time for income earning and saving activities and more balanced gender roles |
| Goal 4: Reduce child mortality: | Target 5: To reduce by two thirds, between 1990 and 2015, the death rate for children under the age of five years | <ul style="list-style-type: none"> • Access to improved quantities and quality of domestic water and sanitation reduces the main morbidity and mortality factor for young children | <ul style="list-style-type: none"> • Improved nutrition and food security reduces susceptibility to diseases |
| Goal 5: Improve maternal health: | Target 6: To reduce by three quarters, between 1990 and 2015, the rate of maternal mortality | <ul style="list-style-type: none"> • Improved health, cleanliness and reduced labour burdens from water portage reduce mortality risks | <ul style="list-style-type: none"> • Improved health and nutrition reduce susceptibility to anaemia and other conditions that affect maternal mortality |
| Goal 6: Combat HIV/AIDS and other diseases: | Target 7: Have halted by 2015 and begun to reverse the spread of HIV/AIDS | <ul style="list-style-type: none"> • Improved access to water and sanitation supports HIV/AIDS affected households and may enhance the impact of home care programmes | <ul style="list-style-type: none"> • Improved health and nutrition and increased incomes reduce susceptibility to HIV/AIDS and the onset of AIDS |
| | Target 8: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases. | <ul style="list-style-type: none"> • Better water management reduces mosquito habitats and the transmission risks of malaria (Prevention) • Reduced incidence of range of diseases where poor water management induces the breeding of vectors and intermediate hosts (Control) | <ul style="list-style-type: none"> • Improved health and nutrition status reduces susceptibility to a range of major diseases |
| Goal 7: Ensure environmental sustainability | Target 9: Integrate the principles of sustainable development into country policies and | <ul style="list-style-type: none"> • Improved water management, including pollution control and sustainable levels of abstraction, are key factors in | <ul style="list-style-type: none"> • Development of integrated management within river basins creates conditions where sustainable ecosystems |

| | | | |
|---|---|---|---|
| | programmes and reverse the loss of environmental resources | maintaining ecosystems integrity and ecosanitation methods reduce water consumption and recycle nutrients and organics | management is possible and upstream-downstream impacts are mitigated |
| | Target 10: Halve by 2015, the proportion of people without sustainable access to safe drinking water and improved sanitation | <ul style="list-style-type: none"> • Actions to ensure access to adequate and safe water for poor and poorly serviced communities • Actions to ensure access to improved and if possible of productive eco-sanitation for poor households | <ul style="list-style-type: none"> • Health and hygiene promotion activities to ensure greater service coverage generates improved health benefits • Develop operation and maintenance and cost recovery systems to ensure sustainability of service delivery |
| | Target 11: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers | <ul style="list-style-type: none"> • Actions to improve water supply and sanitation services for urban poor communities • Actions to reduce water-borne pollution and wastewater discharge and improve environmental health in slum areas | <ul style="list-style-type: none"> • Communities organised around water supply provision better placed to negotiate for other needs |
| Goal 8: Develop a global partnership for development | Target 12: Develop further an open, rule-based predictable, non-discriminatory trading and financial system | | <ul style="list-style-type: none"> • Fairer market conditions make exports from water-based production (e.g. irrigation) viable, generating greater pro-poor growth |
| | Target 13: Address the special needs of the least developed countries.... | | <ul style="list-style-type: none"> • Actions to reform water sector and invest in needs of the poor demonstrate poverty reduction commitments |
| | Target 14: Address the special needs of land-locked countries and small island states | <ul style="list-style-type: none"> • Water problems (e.g. water scarcity, salinity, disasters) major constraint on development in these countries | |
| | Targets 15-18 | <ul style="list-style-type: none"> • Water management not a relevant factor | |

2.2.3 Transmission of water-related disease

Humans rely on water for many aspects of their domestic lives, from essential drinking water to bathing and washing of clothes and appliances, to recreation and aesthetic appeal. The quality of water has, however, been compromised in many areas as a result of pollution from informal settlements, sewerage spills, construction sites, litter, mine dumps, agriculture and other human activities (Davies and Day, 1998) - activities that themselves rely on water resources. One result of such pollution is water that is infested with disease-causing pathogens and chemicals. The substance that is used for cleanliness has become the transmitter of disease.

The next section discusses the classification of types of transmission of water-related diseases. This dissertation focused on diseases transmitted primarily through recreational use of water, and the following section briefly discusses water and recreation before a more detailed review of the various pathogens and diseases associated with recreational water use. Finally this section closes with a discussion of the socio-economic impacts of water-related diseases.

2.2.3.1 Bradley's classification of water-related diseases

Bradley (1977, cited in Cotruvo et. al., 2004) provides a classification of water-related diseases in which he identifies four main categories of disease transmission, namely:

- Water-borne infections
- Water-washed infections
- Water-based infections
- Infections from water-related insect vectors

The first, water-borne infection occurs through ingestion of water contaminated with human or animal wastes containing enteric micro-organisms and chemical waste from industry (Hartnady, 2003). Examples of water-borne diseases include *Typhoid* and *Cholera*. Water-washed infections occur as a result of poor personal and/or domestic hygiene, often in situations where water is not readily accessible. Referred to as 'water scarce diseases', these thrive in impoverished areas, and are further exacerbated by other water-scarcity problems such as food security (Hartnady, 2003). Infections are often of the

externalities – for example scabies, conjunctivitis and trachoma. The third category of transmission – water-based infections - occur as a result of either ingestion of water, or from contact with contaminated water during bathing or recreational activities. The disease pathogens in water-based infections are aquatic organisms such as worms, flukes, and tissue nematodes (Hartnady, 2003), which must spend some part of their lifecycle in the aquatic environment. An example where infection occurs through ingestion of contaminated water is dracunculiasis (from the Guinea worm – *Dracunculus medinensis*), and an example where infection occurs through contact with infected water is Schistosomiasis (commonly called Bilharzia), where the disease pathogen is the trematode genus *Schistosoma*. Finally, infection by water-related insect vectors occur when the insects carrying the disease breed in or near water. Examples include the Malaria mosquito (*Anopheles*) and the Tsetse Fly (*Glossina*).

2.2.4 Recreation and water-related disease

The recreational use of water has increased dramatically in the past few decades, exposing more people to water-related pathogens and routes of disease transmission (Pond, 2005). Ease of travel and water-based tourism activities has also resulted in many exotic diseases being spread to previously uninfected areas of the world (See section 2.2.1.1). The desire of so many people to use water for recreation poses a new problem for policy-makers and officials, as the conventional methods for reducing water-related disease by reducing contact with pathogen-laden water (Esrey et. al., 1990) are nullified (Esrey et. al., 1990). It has therefore become necessary for global authorities to establish management strategies and guidelines for the safe use of water for recreational purposes. Documents such as the *Guidelines for Safe Recreational Water Environments* (WHO, 2003a) and *South African Water Quality Guidelines: Volume 2 – Recreational Use* (DWAF, 1996) provide some insight into the issues associated with recreational water use and disease in South Africa and offer guidelines for management strategies to deal with the unique scenarios that arise.

2.2.4.1 Water testing and monitoring for safe recreational water

Testing of water for recreational use is aimed primarily at setting standards for use, as opposed to future development, which uses drinking water or wastewater testing (Blumenthal et. al., 2001). It is impractical to test for a wide range of specific pathogens

during routine water quality testing, as it is too economically costly and time-consuming (Sundram, et. al., 2002). As an alternative, the most commonly used faecal indicator for water quality testing is the intestinal bacteria, *Escherichia coli*. *E. coli* is present in large numbers in the faecal matter of both humans and animals – and hence present in large numbers in sewerage, it is readily traceable using simple test methods, it does not grow in natural waters, and it exhibits similar persistency and treatment response traits to other water-related pathogens (Fewtrell and Bartram, 2001). In addition, while *E. coli* phages cannot provide an indication of the quantity of enteric human viruses in polluted water, their appearance supports the possible presence of these viruses, as *E. coli* phages generally outnumber enteric viruses in water environments (Grabow, 2001).

2.2.5 Water-related disease pathogens

Communicable diseases infectious diseases transmitted from one organism to another, and are caused when a host is infected with living, multiplying micro-organisms such as animal parasites, bacteria, fungi or viruses. While humans are free of micro organisms before birth, they quickly acquire millions of biotic agents through activities such as eating, drinking and breathing. Most of these are harmless microbial fauna that are not infectious and do not cause disease (EPA, 1993). In many cases they can become pathogenic when they overcome the body's defence mechanisms for some or other reason and are able to penetrate the immune system through intact skin or mucous membranes of the body.

There are a range of water-related organisms which act as pathogens for the transmission of disease, and while many of these result in self-limiting ailments, such as diarrhoea, there are others that can cause severe, even life-threatening diseases (Pond, 2005). Pathogens associated with water-related disease transmission include viruses, bacteria, protozoa, fungi and microsporidia, and helminths, all of which thrive in areas where poor sanitation, bad hygiene and poor land management practices result in disturbed, poor quality water resources. Table 2.7 outlines some diseases associated with recreational use of water, lists the pathogen that causes the disease, the route of transmission, and general symptoms of infection. A brief outline of the different pathogens is provided below.

Viruses, which have no prevalent cell structure, consist of a nuclear substance that is protected by a protein coat, which allows the virus to resist environmental hazards (EPA, 1993). As a result they can survive for a period of time in substances such as milk, soil and water. Viruses are recognised as being host-specific (Cotruvo, et al, 2004) and once infected with a virus, the individual host becomes immune to future exposure to the same virus, which explains the high mortality of children as a result of viral infections. Bacterial micro organisms, while more easily destroyed by environmental hazards, remain the most prevalent life form on earth, and a major cause of biotic diseases. This can be attributed to their incredible versatility and ability to adapt well to varying conditions and driving forces (Cotruvo et al., 2004). Similar in structure to bacteria, rickettsia behave more like viruses, in that they do not usually multiply outside the living cells of their hosts. Rickettsia pathogens convert the metabolism of a host cell to that of their own, effectively debilitating the cells of the host body. In addition, they release endotoxins into the bloodstream, furthering the impact of the disease (Jadin, 2002). Considerably larger than both viruses and bacteria, protozoa are single celled, eukayotic micro organisms, which can survive water treatment by secreting a protective covering and entering a cyst stage (EPA, 1993). Most protozoa associated with water-related diseases are considered to be zoonotic pathogens (passed from animal to human) (Cotruvo et. al., 2004)

Fungal infections are not generally associated with recreational use of water, but cannot be overlooked, as there are some yeasts and moulds that are considered zoonotic and waterborne (Cotruvo et. al., 2004). On the other hand, there are numerous Helminth pathogens transmitted through recreational water-use. Some of these use an intermediate host that is water based.

In addition to the above diseases, a number of sequelae have been identified (Pond, 2005) that occur as a secondary complication of water-related illness. These conditions contribute both to the high level of morbidity associated with water-related illness and to the social and economic failures in poverty-stricken communities that do not have the effective means of dealing with disease.

Table 2.7 Diseases and ailments associated with recreational use of water (Adapted from Pond, 2005 and EPA, 1993)

| Disease (Pathogen) | Transmission route and cause | Symptoms |
|---|---|--|
| <u>Bacterial Infections</u> | | |
| Leptospirosis (Leptospire) | Excreted in the urine and faeces of animals and gain entry to the human host via ingestion or through cuts and abrasions or the mucosal surfaces of the mouth, nose and eyes. | Wide range - from acute flu-like symptoms to fatal manifestations of the disease causing liver and kidney failure, may include jaundice (yellow skin and eyes), red eyes, abdominal pain, diarrhoea, or a rash |
| Cholera (<i>Vibrio cholerae</i>) | Ingestion | Watery diarrhoea, vomiting, occasional muscle cramps |
| Legionella | Inhalation | Fever, cough, prostration, diarrhoea, pleuritic pain |
| <i>E. Coli</i> 0157:H7 | Ingestion, from animal faeces | Severe bloody diarrhoea and abdominal cramps; sometimes infection has no symptoms |
| Campylobacteriosis (<i>Campylobacter jejuni</i>) | Ingestion, animal faeces | Diarrhoea, occasionally bloody and severe. Cramping, abdominal pain, fever, malaise |
| Typhoid (<i>Salmonella typhi</i>) | Ingestion, human excreta | Fever, malaise, aches, abdominal pain, diarrhoea or constipation, delirium |
| Mycobacterial infection | Inhalation | |
| Shigella dysenteriae | Ingestion, human faeces | Severe abdominal pain, watery diarrhoea, or stools containing blood |
| <u>Rickettsia</u> | Contracted through bites from ticks, lice, fleas and mites. Meat, faeces and dust | Various symptoms |
| <u>Viral Infections</u> | | |
| Human Adenovirus - | Ingestion | |

| | | |
|--|--------------------------|---|
| HAV) | | |
| Cocksackie Virus | | |
| Echovirus | | |
| <u>Hepatitis A-E</u> | Ingestion, human excreta | Malaise, weariness, myalgia, arthralgia, fever and sometimes jaundice |
| | | |
| <u>Helminthic</u> | | |
| Schistosomiasis | Skin contact | Itchy popular rash, other symptoms depend on the organ that the organism resides in |
| Cyanobacterial toxicosis | | |
| <u>Protozoa</u> | | |
| Cryptosporidiosis (<i>Cryptosporidium parvum</i>) | | Diarrhoea, mild abdominal pain, mild fever |
| Giardiasis (<i>Giardia lamblia</i>) | | Acute onset of diarrhoea, abdominal cramps, bloating and flatulence, malaise, weight loss |

2.2.6 Socio-economic impacts of water-related disease

The impacts of water-related disease are closely related to those of water degradation. There is an increase in the rate of mortality, and the level of morbidity in communities coping with disease and poor living conditions. Loss of ecological services and safe water sources as a result of pollution inhibits the capacity of wetlands and other purifying ecological systems to function, and water resources become costly entities to manage and unpleasant places to be. In association with the growing population, and resulting increase in pollution and degradation, there is an increased demand for safe drinking water to satiate societies. The cost of provision of this water is steadily increasing as the healthy resources become more and more scarce (Lindqvist, 1998).

Costs of water-related illness to people in poorer communities, who are not aware of their ailment and not informed of their options for treatment, are extensive. Their lives are impeded by sickness, lost educational time due to absence from school, lost employment opportunities and, for many, death and the associated loss and trauma for the families left behind (Gleick, 2002). The impact and costs of increasing water-related diseases on health services and facilities is also a considered a factor in the burden of disease. Valuable resources and staff are absorbed through treatment of patients with avoidable illnesses, and those with more serious diseases are further weakened by secondary inconspicuous infections such as Schistosomiasis. These costs and impacts can be avoided through improved sanitation conditions and education, as well as improved treatment campaigns. An example of how treatment of water-related illnesses is effective is provided by Vorster et. al. (1997) in showing how treatment of many Helminth infestations, such as Schistosomiasis among school children, has been proven to improve concentration and school attendance levels, appetite, physical health and fitness (Vorster et. al., 1997). The impact of disease on communities is hardest felt in the children, whose generation will suffer in the future as a result of poor nutrition by parasite absorbing nutrients, retarded physical growth and poor school performance and attendance (SEI and UNDP, 2005).

2.3 Integration of Water Resource Management and Human Health

This chapter, through a discussion of available literature, has shown how the management of water resources, and the management of health issues related to water-related diseases are integrated.

The ecological health of river systems relies heavily on the condition of the environment through which it flows, and is therefore influenced by human use of land and water resources. If these resources are degraded, and their ability to regenerate and provide goods and services is compromised, they begin to indirectly contribute to human health problems as a result of pathogens that thrive in disturbed ecological regimes. In a similar manner, where human health conditions are poor, and communities survive under the burden of lessened education and retarded economic growth, as a result of poor productivity as they use their resources to fight illness, river resource integrity is compromised.

Global and local authorities have started to employ strategies to reduce both the degradation of natural resources, including water resources, and the global problem of ill health. Internationally, multi-lateral strategies such as the Millennium Development Goals have set high targets to combat these problems, and progressing toward them requires the cooperation and collaboration of everyone concerned. Monitoring of progress towards these goals suggests that they may not be met by their 2015 time-scale, and that enough is not being done by some of those in power. However, the goals set a precedent towards which humanity can advance and set in motion an ongoing activity that addresses many of the concerns that have been overlooked in the past.

In a similar vein, the South African government has promulgated strategies, such as those in the National Water Act (NWA), to regulate and mediate the use and management of water resources. Many of the actions laid out in the NWA have yet to be implemented, but their existence provides a structured path for progression that is integrated in both its approach and proposed outcomes. Ensuring that the goals of this and similar strategies are justly and positively implemented will require the cooperation and input of all members of the South African society, from those in power, to those utilising the resources. One such resource, currently in the grips of all of the above-mentioned social and legislative activities and problems, is that of the Mngeni and Msunduzi catchments. This is discussed in chapter 3.

CHAPTER THREE

THE MSUNDUZI/MNGENI CATCHMENTS

3.1 River health and description of Msunduzi/Mngeni catchment environment

This chapter provides an overview of the ecological condition of the Msunduzi and Mngeni catchments and identifies unresolved issues and problems of resource use and pollution. Canoeists are one group of river users who utilise the resource for recreation and professional sport, and play an important role in identifying problems and initiating action. Their role is discussed in more detail here, followed by an outline of the management strategies and responsible bodies employed in the catchment. The chapter also discusses some local water-related diseases and highlights the burden of these diseases to the social and economic prosperity of the communities in the catchment.

3.1.1 State of the River

In an effort to gauge the condition of South African rivers and streams, to enhance environmental management and decision-making, the Department of Water Affairs and Forestry (DWAF), in collaboration with the Water Research Commission (WRC), established the River Health Programme (RHP). This initiative was designed to generate objective and scientifically sound information on the state of health of river systems at a catchment or regional scale (WRC, 2002). In 2002, the *State of the Rivers Report: uMngeni River and Neighbouring Rivers and Streams* (WRC, 2002) was published. This document provides an easy-to-use account of the river health of the various sections of the Mngeni and Msunduzi rivers from source to sea. The RHP uses a set of five indices to assess the health of the river:

- Water Quality Index
- Index of Habitat Integrity (IHI) – Riparian Zone
- Index of Habitat Integrity (IHI) – Instream Habitat
- South African Scoring System for aquatic invertebrates (SASS)
- Fish Assemblage Integrity Index (FAII)

The Water Quality Index uses variables typically associated with faecal contamination - *E. coli*, turbidity, conductivity, nitrate, ammonia, total and soluble forms of phosphorus, suspended solids and total organic carbon, which are collected by the local water management organisations in their routine monitoring, to determine deteriorating water quality. The Index of Habitat Integrity gauges ecosystem health and the impact of disturbances on fauna and flora both in the in-stream environment, and the riparian zone. Aquatic invertebrates are included in the assessment using the South African Scoring System (SASS) (Dickens and Graham, 2002), which is based, primarily on sensitivity rankings of families of aquatic macro-invertebrates, but also uses crustaceans and molluscs. Fish assemblages of both numbers of species and size of are determined using the Fish Assemblage Integrity Index (FAII) (Kleynhans, 1999). The interpretation of these indices results in the establishment of standardised river health classes (Table 3.1), which are used to describe the condition of different sections of the river (WRC, 2002).

The following description of the river catchments uses the river health classification (Table 3.3) as provided in the State of the Rivers Report (SoR) (WRC, 2002), and a diagrammatic outline summary of the reports River Reaches Water Quality is illustrated in Figure 3.1.

Table 3.1 River Health Classes (WRC, 2002)

| River Class | Health | Ecological perspective | Management perspective |
|-------------|--------|---|---|
| NATURAL | | No or negligible modification of in-stream and riparian habitats and biota. | Protected rivers; relatively untouched by human hands; no discharges or impoundments allowed. |
| GOOD | | Ecosystems essentially in good state; biodiversity largely intact. | Some human-related disturbance but mostly of low impact potential. |
| FAIR | | Sensitive species may be lost; lower abundances of biological populations are likely to occur, or sometimes higher abundances of tolerant or opportunistic species occur. | Multiple disturbances associated with need for socio-economic development, e.g. impoundment, habitat modification and water quality degradation. |
| POOR | | Habitat diversity and availability have declined; mostly only tolerant species present; species present are often diseased; population dynamics have been disrupted (e.g. biota can no longer reproduce or alien species have invaded the ecosystem). | Often characterised by high human densities or extensive resource exploitation. Management intervention is needed to improve river health - e.g. to restore flow patterns, river habitats of water quality. |

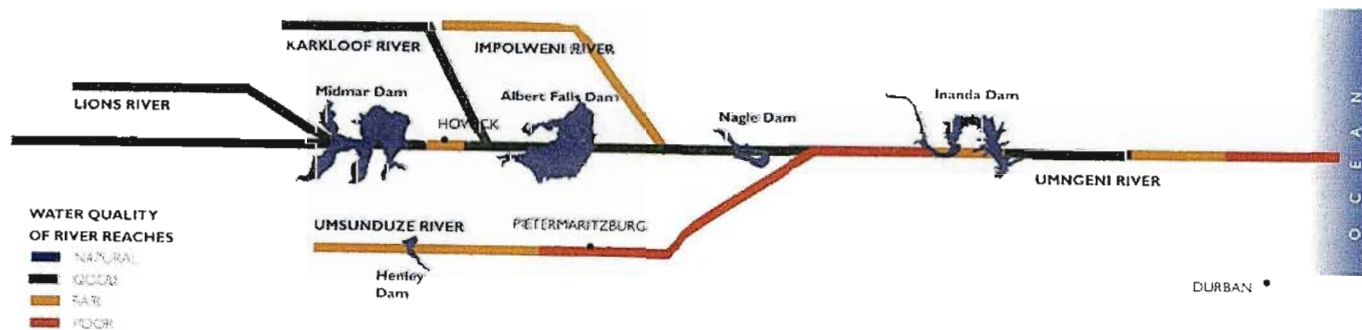


Figure 3.1 Water quality of the various river reaches of the uMngeni River and its tributaries (Adapted from WRC, 2002)

The uMngeni River (Figure 3.2) of which the Msunduzi is a major tributary, is located in one of the most industrialised and built-up areas in South Africa, and has been classified by the Department of Environmental Affairs and Tourism as 'threatened' as a result of over-utilisation (Beharie, 2005). While the catchment is not a water-stressed area, water that is available is of a poor quality as a result of mismanagement of the surrounding area and pollution.

The river rises in the uMngeni Vlei Wetland area in the Western escarpment, and flows eastwards towards the Indian Ocean over a distance of 255km from source to mouth. The upper reaches of the river are classified as natural to good (WRC, 2002), as the river flows through areas characterised by pastoral farming and forestry and there are numerous wetlands, which serve to rejuvenate the stream. Environmental issues in the area include loss of wetlands due to increased human activities, silviculture causing erosion and destabilisation of river banks; and agricultural. The first major settlement is Howick, below Midmar Dam. In Howick, the uMngeni flows over Howick Falls (111m natural waterfall), and the river channel narrows and flows along a much steeper gradient through the Umgeni Valley Nature Reserve. The intensity of agriculture increases above and immediately below the Albert Falls dam, and the impact on the instream habitat health is noticeable (WRC, 2002).

Between Albert Falls and Nagle Dam, the river descends into steep, mountainous terrain and there is a dramatic reduction in both human activities and human settlements, and the river condition improves. The river health above Nagle Dam is considered good. Between Nagle Dam and Inanda Dam, the uMngeni flows through disturbed land where subsistence agriculture is the main activity and settlements lack adequate sanitation services. Over-grazing and the resulting erosion have led to a high silt level in the river, and illegal sand winning is evident above the dam. The quality of the river reach is classified as "poor", with primary causes attributed to altered vegetation regime as a result of overgrazing and excessive pollution entering the river from the upstream areas of Pietermaritzburg and the Msunduzi River (WRC, 2002). The removal of silt and impurities – trapped in the dam – results in the section immediately below Inanda dam being in a good ecological condition (WRC, 2002; Ethekewini Municipality and Groundtruth, 2006). While water quality tests immediately below the dam may show a healthy macro-invertebrate balance, and good fish assemblages, the entrapment of silt in

the dam is detrimental to the longer-term health of the river as it destabilises the erosion/deposition equilibrium that is essential for habitat formation within the river. In addition, the lack of water releases from the dam starves the system of the vital reserve water required for ecological functioning (DUCT, 2006), and those releases that are made are from the base of the dam wall, with the result that they are considerably colder than would naturally flow in the area. The changed temperature regime has a dramatic effect on the natural habitats below the wall, and fauna and flora are significantly affected (WRC, 2002).

As the river progresses towards Durban, the human disturbances increase dramatically and by Blue Lagoon, where the river flows into the sea, the state of ecological health is very poor (WRC, 2002). The 2006 SoR report does not include a survey of the section of river from the Silver Pipe to Blue Lagoon, some ten kilometres through heavily industrialised and urban landscape. The reason given in the report is based on the site at Silver Pipe being the final accessible area with rapids and riffles allowing for invertebrate surveying. Up to this final survey point, the ecological state is recorded as being 'good' (Ethekewini Municipality and Groundtruth, 2006). This indicates a significant discrepancy between the 2002 report and the 2006 results for the lower uMngeni river. Additional observations on the lower section by members of the canoeing fraternity (Personal communication, 2006), however, indicate that the condition of the river is, visually, appalling. Not including a survey in the 2006 report gives a misleading result of the uMngeni River as a whole.

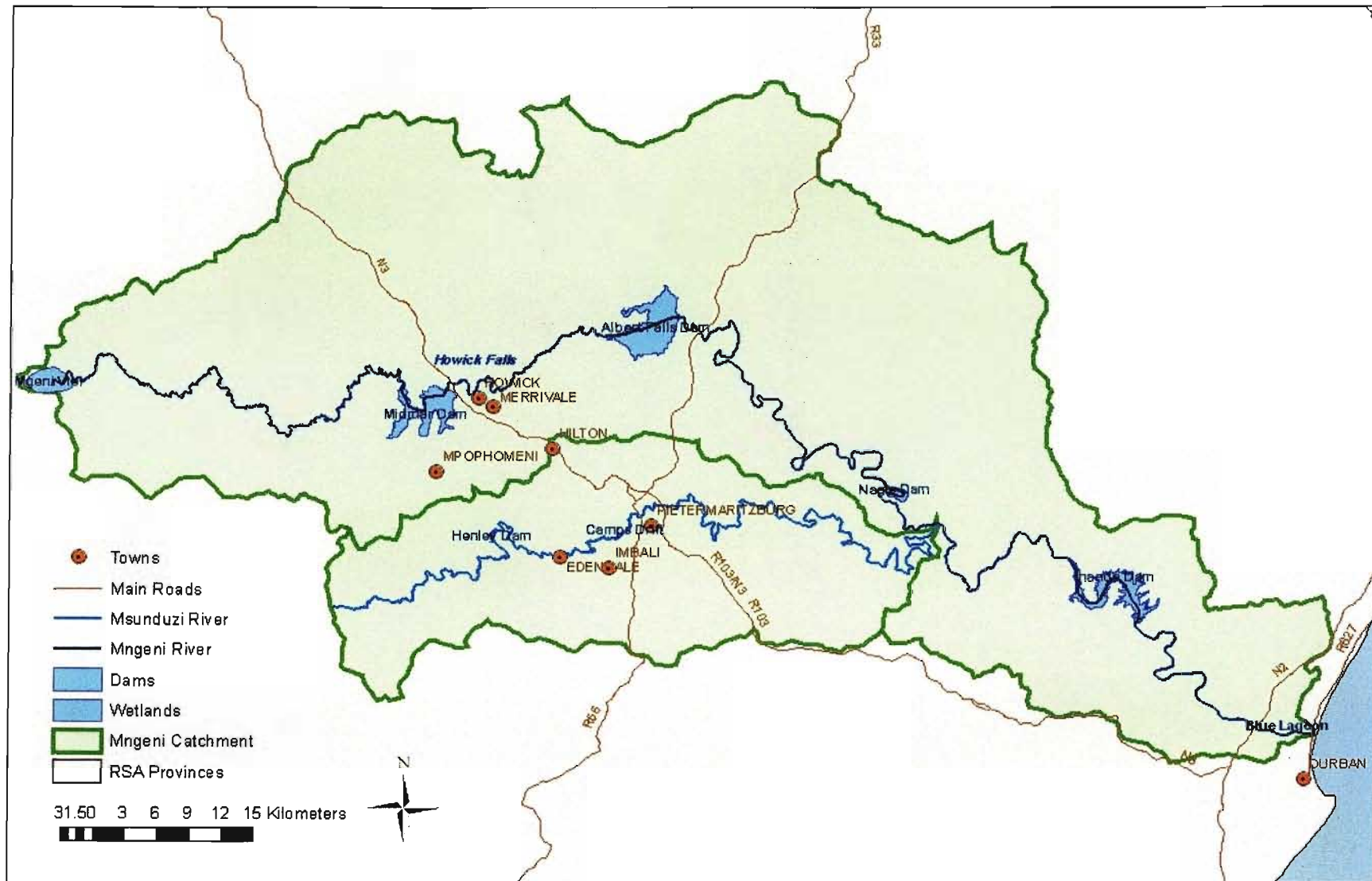


Figure 3.2 Mngeni Catchment - including Msunduzi and Mngeni Rivers

The issues of urban river environments are discussed in WRC (2002), and include increased runoff from concreted surfaces, increased pollutants from industry and sewerage loads, litter, and alterations to stream structure such as canalisation and diversions. All of these issues impact heavily on the instream ecology of the river and could potentially be averted or mitigated through appropriate catchment management. Table 3.2 provides a summary of the goods and services provided by the Mngeni and Msunduzi rivers and the threats to those goods and services as highlighted by the Water Research Commission in the 2002 State of the Rivers Report (WRC, 2002).

Environmental problems in the Msunduzi catchment include: overgrazing and poor farming practices, which lead to land degradation and soil erosion; poor sanitation and water supply services, resulting in poor living conditions and high levels of sewerage contamination in the river; and industrial pollution. Another factor contributing to the degradation of the Msunduzi River is that of alien plant infestation, both in the river and on the banks. Alien plants alter the riverine habitats by transforming the flow of nutrients and processes within the system, which threatens the health of many naturally occurring plants and animals (Richardson and Wilgen, 2004). These changes affect the ability of the river to recover from anthropogenically induced damage and pollution.

The Msunduzi River is one of the major tributaries of the uMgeni River. The catchment flows through the Edendale valley, Pietermaritzburg, a highly disturbed area characterised by subsistence cultivation and high-density rural developments. The river health of this upper section of the catchment is classed as fair (WRC, 2002), with overgrazing, inadequate sanitation removal and industry contributing to the problems in the area. The river then flows through the heavily industrialised city of Pietermaritzburg, and joins the uMngeni in the Valley of a Thousand Hills. Ecological health in this section of the river is reported as 'poor' in the 2002 SoR. The more recent, 2006 SoR of the Ethekwini Municipality (Ethekwini Municipality and Groundtruth, 2006) classes this stretch as 'good'. However, the year upon which the more recent report was based (2005-2006) received a higher summer rainfall than usual, and many of the pollutants may have been washed out at the time of the assessment, and the results are not a true reflection of the state of the river in time.

Table 3.2 Summary of goods and services provided by sections of the Msunduzi and Mngeni Rivers and the threats posed by human activities (Adapted from WRC, 2002)

| River Reach (Overall condition) | Goods and Services | Threats |
|--|---|---|
| Midmar - Mngeni source to Midmar Dam | <ul style="list-style-type: none"> • Provision of potable water to much of the province's cities • Wetlands filter water and act as temporary storage in dry seasons • Water for extensive agriculture and silviculture • Provision of habitat for endangered and rare species - e.g. wattled crane in the Mngeni vleis • Provision of areas for sport and recreation - fishing, canoeing, swimming - and brings income into the area through sporting events (Midmar Mile) | <ul style="list-style-type: none"> • Wetland Degradation • Erosion and sedimentation due to silviculture and alien plant infestation • Midmar Dam - man-made reservoir flooded wetlands • Nutrient input from livestock agriculture in the area • Potential impact of inter-transfer basin from Mooi River - change in flow regime and introduction of biota |
| Albert Falls - Midmar Dam to Nagle Dam | <ul style="list-style-type: none"> • Tourism and recreation in Howick and on Albert Falls Dam and Nagle Dam, with accommodation, fishing, game viewing and water sports available • Environmental education and tourism at Umgeni Valley Nature Reserve and various game reserves in the area • Use of the river by the community at iMpolweni for recreation, drinking water, fishing etc. • Good quality water for agriculture and forestry • Angling opportunities • Albert Falls dam and Nagle dam are the main water supply reservoirs for the greater Durban area | <ul style="list-style-type: none"> • Unnatural water releases from Albert Falls dam disturb ecological processes • Silviculture in upper areas result in lessened flow • Excessive nutrient infiltration from intense cattle feedlots • Discharges of effluent from Howick and poor sanitation and land management at iMpolweni have considerable impact |
| Upper Msunduzi - Msunduzi source to Edendale | <ul style="list-style-type: none"> • River dilutes pollutants from the river and peri-urban developments • Water supply for agriculture • Recreation and subsistence fishing • Reeds • Cultural and spiritual activities held in | <ul style="list-style-type: none"> • Severe overgrazing has resulted in high erosion levels and degradation of the river banks and turbid water. • Nutrient pollution from sewerage from informal settlements with no waste services |

| | | |
|---|---|---|
| | <p>the riverine resource</p> <ul style="list-style-type: none"> • Domestic clothes washing | <ul style="list-style-type: none"> • Sewer surcharges - often during flood events • Industrial effluent pollution and illegal discharges • Henley dam - decommissioned - but still has impact on river ecology as it is an unnatural reservoir |
| Pietermaritzburg | <ul style="list-style-type: none"> • Dilution and removal of domestic and industrial pollutants • Water for informal domestic use • Subsistence and recreational fishing • Water resources for contact recreational sport, such as canoeing and income generated in the area from events e.g. Dusi Canoe Marathon • City green area in the form of Alexandra Park • River-based educational activities | <ul style="list-style-type: none"> • Highly built up area with high population densities results in increased pollution and increased run-off • Over-worked sewers overflow into river • Illegal industrial discharges directly into the river • Altered river-bed (canalisation and removal of riparian vegetation) results in increased damage from flood events • Alien plants and trees have altered the instream habitat by increased shading and destabilisation of banks |
| Inanda - Pietermaritzburg/Nagle Dam to Inanda Dam | <ul style="list-style-type: none"> • Instream purification of polluted water • Potable water supply for Durban area • Rural communities use river for watering stock and agriculture • Sand mining generates income • Tourism and sporting opportunities available in river and on Inanda Dam • Crafts from riparian plants - e.g. ikhwane and imizi • Potential for valuable products such as medicinal plants - now threatened | <ul style="list-style-type: none"> • Disturbance created by upstream dams • Inanda dam blocks estuary fish from moving upstream • Over-grazing and over-use of land in the 'Thousand Hills' area has resulted in poor vegetation cover, high erosion and infestation of alien plants among others • Excessive subsistence fishing • High infestation of alien aquatic plants choke riverine habitats • Sand mining, both legal and illegal alter the morphology of the river and disturb natural processes and habitats |
| Lower Mngeni - Inanda Dam to Durban | <ul style="list-style-type: none"> • Transport and dilution of domestic and industrial waste • Estuary at Durban provides a nursery for marine fishes and a venue for sport angling and subsistence fishing. | <ul style="list-style-type: none"> • Highly industrialised urban area, with high modification of river course • Extensive canalisation of the river has resulted in an unnatural water body with no natural habitats |

| | | |
|--|---|--|
| | <ul style="list-style-type: none"> • Blue Lagoon with its Beachwood mangrove used for recreational and educational activities • Sand mining • Flood plain used for building (at a high ecological cost) • Cultural and spiritual activities • Canoeing from Inanda Dam to Durban • Durban Metropolitan Open Space along the river | <ul style="list-style-type: none"> • High population densities, effluent discharge, excessive nutrient and effluent discharges, polluted run-off from city streets and from factories and informal settlements • Upstream river activities and instream infrastructure for water abstraction and use have altered rivers flow regime • High infestation of alien aquatic plants, in particular Water Hyacinth |
|--|---|--|

The incidences of contamination and degradation of the Msunduzi River as a result of industrial spillage, sewerage overload, waste dumping and infrastructural damage are well documented in the local press (Table 3.3). Covering the past five years there have been severe industrial effluent leaks or dumps (See Table 2.1); faecal contamination as a result of poor infrastructure in rapidly expanding low income housing and 'squatter camps' (Bishop, 2002a) and sewerage overflows as a result of insufficient infrastructure to cope with sewerage loads in high rainfall episodes (Bishop, 2002a). Urban infrastructure and development that disturbs the natural vegetation has been reported to result in severe cases of erosion, which jeopardises the stability of the banks, and results in a high level of sediment in the stream and loss of topsoil (Bishop, 2002b). Contributing to the problem are numerous incidents of non-point source pollution. Non-point sources of pollution can accumulate from a variety of different sources, which in isolation would not be cause for alarm, but combined create more contamination than all point source pollution from industry and sewerage overload (Dent, 2004). Littering and dumping of domestic waste (Bishop, 2005a) is not only aesthetically destructive on the riverine environment, but the decay of packaging and other man-made materials releases numerous toxins into the water. The disturbance of riverine ecosystems often results in infestation of alien plants (Bishop, 2005b) that out-compete indigenous species, destabilise banks and disrupt the natural flow of the system. In addition to the reports of pollution and contamination of the river, there are articles relating to municipal management problems and the failure of those in authority to take action against those responsible for the pollution (See Table 3.3)

One article in the Natal Witness newspaper (Naidoo and Parker, 2006) discusses the responsibility of national and provincial departments in charge of environmental affairs, and their lack of political will in taking effective action against polluters. According to the article, communities and lobby groups place the blame of ongoing pollution and resulting river degradation on the municipality and city departments. Accompanying the front-page article is a photograph (Figure 3.3), taken of the accumulated waste clogging the Msunduzi River at a low level bridge on the edge of the city. It appears that most of the accumulated rubbish is domestic litter that has been washed into the river from the banks during high water events - litter that has been discarded by members of the community. The photograph places a certain irony on the situation and highlights that, while municipalities and administrative bodies have a responsibility to ensure the effective management of pollution, individuals in the community have an equally important

responsibility to ensure they do not contribute to the pollution problem by negligently littering. The issue is further complicated by the poor provision of municipal waste services to effectively remove domestic waste from upstream communities. The problem is by no means a simple one, and requires action by both municipal authorities and the public. Instead, each one blames the other and no effective action is taken.

Table 3.3 The Natal Witness newspaper articles covering contamination of the Msunduzi River over the past five years

| TITLE OF ARTICLE & DATE | INCIDENT | POLLUTION TYPE | REFERENCE* |
|--|--|-----------------------|------------------|
| Gov't Backs City on Pollution, 28 September 2001 | Toxic furnace oil spillage into the Dorpspruit, a tributary of the Msunduzi - PG Bison | Industrial | Bishop, 2001 |
| Authorities Investigate Polluted Baynespruit, 30 November 2001 | Polluted water discovered during clean-up operation - unknown culprit | Industrial | Hadebe, 2001 |
| Cries of a Dying Waterway, 5 February 2002 | Research findings indicate high levels of toxic pollution discharged into the Baynespruit tributary - industries | Industrial | Sherriffs, 2002 |
| Authorities Investigated Polluted Baynespruit, 5 February 2002 | Spillage of toxic furnace oil into Dorpspruit - PG Bison | Industrial | Hadebe, 2002 |
| Duzi water quality improves radically, 5 February 2002 | Numerous sewerage breaks in the city, and overload of the sewerage works as a result of high rainfall | Sewerage | Regchand, 2002 |
| Fire Dept prevent environmental disaster after tanker spill on N3, 11 March 2002 | Potential pollution of water course following spillage of Bitumen from truck collision on motorway | Chemical | Bishop, 2002 |
| Red Alert for City Rivers, 7 October 2002 | Release of the 2002 'State of the Rivers Report' stating that 'Pietermaritzburg has some of the most polluted rivers in the province'. | All | Bishop, 2002 |
| Authorities to Tackle Townbush Stream's Red Tinge, 15 August 2002 | Concerns raised over the red colour of the stream during the rainy season. | Agriculture - erosion | Bishop, 2002 (b) |
| Tannery Manager Tries to Clean Up, 24 October 2002 | Waste dumps sites and polluted dams on tannery location contributing to pollution of Msunduzi tributaries | Industrial | Bishop, 2002 (c) |
| Lack of rain, algae causing | Algal blooms in the river as a result of long period | Sewerage | Bishop, 2003 |

| | | | |
|--|--|-----------------------------------|------------------------------|
| red-green Duzi, 14 February 2003 | without rain and high level of nutrient from sewerage pollution in the river | | |
| Probe into Alleged Toxic Waste, 14 October 2003 | A previously reported backyard recycling business caught with toxic waste leaching into the groundwater near their business. | Industrial, recycling waste | Kockott, 2003 |
| Hulett Aluminium funds clean-up after oil spills into Duzi, 19 July 2003 | Industrial accident at Hulett Aluminium resulted in spillage of aluminium cutting oil into Msunduzi River | Industrial | Bishop, 2003 |
| Huletts warned over toxins in Duzi, 21 January 2004 | Potential contamination of river water with highly toxic Chrome III and Chrome VI from Hulett Aluminium effluent treatment plant | Industrial | Bishop, 2004 |
| Industries apply to use rivers as dumps, 8 August 2004 | City industries apply for permission from the municipality to continue pumping effluent into the cities water system | Industrial | Harms and Bishop, 2004 |
| Confronting our mess, 12 August 2004 | Discussion of the contribution of non point-source pollution and government role in management | Point source and non-point source | Dent, 2004 |
| Managing water catchment areas, 16 Aug 2004 | Discussion of public role in formation of management agencies, and social responsibility | Legislation | Dent, 2004 |
| Spoornet denies spill fears, 20 April 2005 | Spill of toxic chemicals after train crash near the Dorpspruit - Spoornet | Chemical | Saville, 2005 |
| Progress in clean-up of chemicals, 28 April 2005 | Follow-up of toxic chemical spill into Dorpspruit - Spoornet | Chemical | Saville, 2005 (b) |
| No more waiting for officials, 24 May 2005 | Group of concerned citizens make effort to clean up the river environment | All | Bishop, 2005 |
| Tackling river health, 6 December 2005 | Establishment of Dusi-Umgeni Conservation Trust (DUCT), an action group to deal with issues of river health. | All | Bishop, 2005 (b) |
| Umgeni River vs. Umgeni Water, 13 July 2006 | Landslide caused by broken Umgeni Water Pipeline | Erosion, environmental damage | Boothway, 2006 |
| Who is killing the Duzi? 25 July 2006 | Numerous pollutant discharges into Msunduzi, resulting in death of fish - polluter unknown | All | Bishop and Waka-Zamisa, 2006 |
| Septic City, 26 July 2006 | Opinion article on management initiatives failure to resolve pollution issues | Industrial | Anonymous |
| Govt fed up with dirty Duzi, 26 July 2006 | Stakeholder and interest parties question the municipal managers for not bringing offenders to task | Industrial | Bishop, 2006a |
| Pollution of the Msunduzi River, 26 July 2006 | Letters from the public regarding their concerns for domestic water use from the river | | Still, 2006; Lind, 2006; |

| | | | |
|--|---|------------------------------------|-------------------------|
| | | | Law, 2006; |
| Pollution team fails to take off, 26 July 2006 | Failure of the city authorities to bring issues to the table. No-one is willing to take responsibility or action | All - no action | Naidoo, 2006 |
| Polluted Duzi, 27 July 2006 | Opinion article on regulation and management | | |
| More dead fish as search for polluters continues, 28 July 2006 | Umgeni Water unable to pinpoint the ongoing source of pollution responsible for the death of numerous fish in the river | All | Mbanjwa, 2006 |
| Businesses and govt help clean up city's main river, 12 September 2006 | In collaboration with World Clean-up Day, DUCT organises a city river clean-up, involving numerous communities, organisations and businesses | Litter, solid pollution | Bishop, 2006b |
| Cleaning up the city's act, 18 September 2006 | Opinion regarding city pollution problem, highlights that although there is activity, more input is required on all fronts | Litter, pollution | Alberts, 2006 |
| Two thousand bags filled in Duzi river clean-up, 18 September 2006 | Report on the clean-up of the Duzi river on World Clean-up day. | Litter, solid waste, pollution | Wake-Zamisa, 2006 |
| Disgust at Dirty Duzi, 18 October 2006 | A massive accumulation of waste in the course of the Duzi spurred an outcry from local residents about the lack of action taken by city officials | Litter - no action by municipality | Naidoo and Parker, 2006 |

* All references jointly accessible from the Natal Witness, or online at www.witness.co.za



Figure 3.3 Front-page newspaper photograph (The Natal Witness, 18/10/2006, pg. 1) highlighting river pollution problems and the lack of will of authorities to take effective action.

3.1.2 Recreational water and disease

One of the major services provided by the water resources of the Mngeni and Msunduzi Rivers is that of recreational sport including swimming, fishing and, for the purposes of this research, canoeing. These recreational activities are threatened by the risk of contracting water-related diseases rife in the contaminated waters of the two rivers. To try and alleviate the risk, the South African Department of Water Affairs and Forestry have issued a set of guidelines for the safe recreational use of water (DWAF, 1996a, b). The purpose of the guidelines is to provide information for water quality managers and other interested and affected parties on the safety of various recreational activities associated with water. The guidelines are detailed, giving information on all aspects of risk associated with recreational use of water, from full immersion (swimming) to intermediate (canoeing) to no immersion activities (picnicking). Despite the guidelines, however, disease continues to be a major limiting factor in water-related recreation and sport in KwaZulu-Natal.

A comprehensive list of water-related diseases commonly contracted during recreational use of water was discussed in Chapter 2 (See Table 2.7). For the purposes of this dissertation, two of these – diarrhoeal infections and Schistosomiasis are discussed in more detail below, as they are the diseases most commonly reported by canoeists in the study area (personal observation).

3.1.3 Diarrhoeal infections

Of water-related infections, diarrhoeal diseases are the most common and are the highest cause of morbidity and mortality, with between 15-34% of global deaths from water-related diseases associated with this (WHO, 2003b). The highest incidences of diarrhoeal infections in the world occur in sub-Saharan Africa, with most cases occurring in children under five years of age (Bern, 2004).

Diarrhoeal infections are transmitted from faeces via oral contact – consuming food that has been rinsed in contaminated water, drinking contaminated water or by oral contact with dirty hands or objects - into the body (Esrey et. al., 1990). Pathogens do not require an intermediate host. The health status of the infected individual will determine the

severity of resulting diarrhoea, with weakened, malnourished children most at risk. Diarrhoea causes dehydration and loss of electrolytes, which increases the severity of the illness, and without treatment, can eventually lead to death.

The enteric bacteria *Cryptosporidium parvum* and *Giardia lamblia* are recognised as major pathogens of diarrhoeal related infections. Both of these have been found to be endemic in KwaZulu-Natal (Jarmey-Swan et. al., 2001).

3.1.4 Schistosomiasis

The disease Schistosomiasis, or Bilharziasis (after German physician Theodor Bilharz) (Mott, 2004) is ranked second, behind Malaria, in diseases affecting the social and economic well-being of populations in tropical and sub-tropical areas. Globally, an estimated 200 million people are infected with the disease, with an approximate 80% of all transmissions occurring in Sub-Saharan Africa (Hartnady, 2003). It is so commonly misunderstood that in some cultures in Africa, blood in the urine – which is a symptom of severe infection – is recognised as a ritual sign of the transition of a child into adulthood (Davies and Day, 1998).

Schistosomiasis is caused by a parasitic flatworm, or trematode, of the phylum Platyhelminths, and genus *Schistosoma* (Behrman, 2005). Of the five species known throughout the world, three are prevalent in Africa, *Schistosoma mansoni* and *S. intercalatum*, which invade the blood of the intestines, and *S. haematobium*, which locates in the blood vessels of the bladder and causes urinary Schistosomiasis (Davies and Day, 1998). Two other species, *S. japonicum* and *S. mekongi* are found on other continents – such as Asia and Islands off the South East Asian mainland. For the purposes of this dissertation, however, only the two prevalent in South Africa – *S. mansoni* and *S. haematobium* – will be discussed in further detail.

The lifecycle of the Schistosome parasite starts when eggs of the adult trematode worm, which lives in the abdominal blood system of mammalian definitive host – human or domestic livestock – (Brown, 1994), is released through faeces (*S. mansoni*) or urine (*S. haematobium*) excretion. If the eggs reach water, they hatch to release small miracidia,

which swim through the water by means of tiny hairs. In the water, the miracidia have approximately 8-12 hours to find and infect an intermediate host – a suitable snail. *S. mansoni* invades the species *Biomphalaria pfeifferi*, and *S. haematobium* uses the snail species *Bulinus globosus* and *B. africanus* as their intermediate hosts (Mollusca: Planorbidae)(Brown, 1994). Once inside the snail, the miracidium locates the liver, and over a period of 4-6 weeks divides multiple times by asexual reproduction to produce thousands of cercaria. These break out of the snail, into the water, where they set about locating a human or animal host. The cercaria enter the body through any part of the exposed skin, and make their way into the blood vessels of either the intestines or the bladder. Here they develop into adult worms. As adults, the female worm lives permanently in a groove in the elongated body of a male worm, and produces up to 200 eggs per day (Mott, 2004). The eggs have tiny hooks, which catch onto the walls of the blood vessels and cause ruptures as more eggs are blocked in the narrow vessels. These ruptures allow some eggs to be released into the bladder or intestine and expelled from the body through excretion. Remaining eggs are transported throughout the body in the bloodstream and inhibit the body's normal functioning, often resulting in heavily infested individuals feeling listless and drained (Davies and Day, 1998).

Schistosomiasis can be easily and effectively treated using one of three safe, and effective drugs, the most effective against all strains of the parasite, and the most commonly used across the globe being Praziquantel (Mott, 2004; Reich, 1998). The long-term eradication of the disease is, however, difficult at this stage in medical science, and re-infection is common, with re-treatment being required as often as once a year. While vaccine research is being undertaken, no safe, effective drug has yet been released (Bergquist, 1998; WHO, 2006).

3.1.4.1 *Schistosomiasis in the Msunduzi/Mngeni Rivers*

In the face of increasing pressures to treat and deal with issues surrounding such pandemic diseases as HIV/Aids and outbreaks of more debilitating and chronic illnesses such as Malaria, the plight of *Schistosomiasis* takes a backseat (Waddington, 2001; TDR, 2002). Although the mortality rate of the disease is considerably less of a social priority than those previously mentioned, it is the morbidity due to infection and secondary

complications associated with the disease that rank Schistosomiasis among the world's most debilitating.

The disease can affect both humans and mammalian domestic livestock (Brown, 1994), which adds to the transmission of disease when the waste from domestic livestock enters the water source and is washed downstream. Livestock farming is practiced extensively in the Mngeni and Msunduzi catchments on both a subsistence and a commercial level, and its contribution to the spread of disease is compounded by indirect river degradation as a result of overgrazing and feedlots. An additional contributing factor to the spread of the parasite includes the impacts of increased water temperature, which encourages the spread of the host snail into previously uninhabited areas. Temperature increases occur as a result of poor catchment management practices and resulting degradation of the river system. Over-utilisation of the resource results in a lower base-level flow of the river, and a shallower river heats up more quickly. Future global climate change may also have an impact on the temperature regime of the river.

Among the canoeing fraternity in KwaZulu-Natal, Schistosomiasis is regularly diagnosed (Anderson, 2006), and is sometimes so commonplace that individuals administer themselves with Praziquantel prophylactically on an annual basis. In recent years, a number of local (Pietermaritzburg-based) canoeists have suffered from acute Schistosomiasis that has manifested itself in life-threatening complications, with the formation of cysts on the brain (Case 47 – Appendix D) and spinal obstruction causing paralysis (Case 36) being some of the more severe disorders. In addition, many doctors and public alike are not well-informed about the disease and it can be misdiagnosed, as was the case with Case 36 (Appendix D), who was initially diagnosed as having a spinal tumour, which would need surgery with a 50% chance of walking again. While the Schistosomiasis was severe, treatment is highly effective if administered timeously, and recovery was far more effective than recovering from surgery. While these complications are in the minority among canoeists, it should be noted that canoeists form a very minor community of the population of river users exposed to the disease along the Msunduzi and Mngeni Rivers.

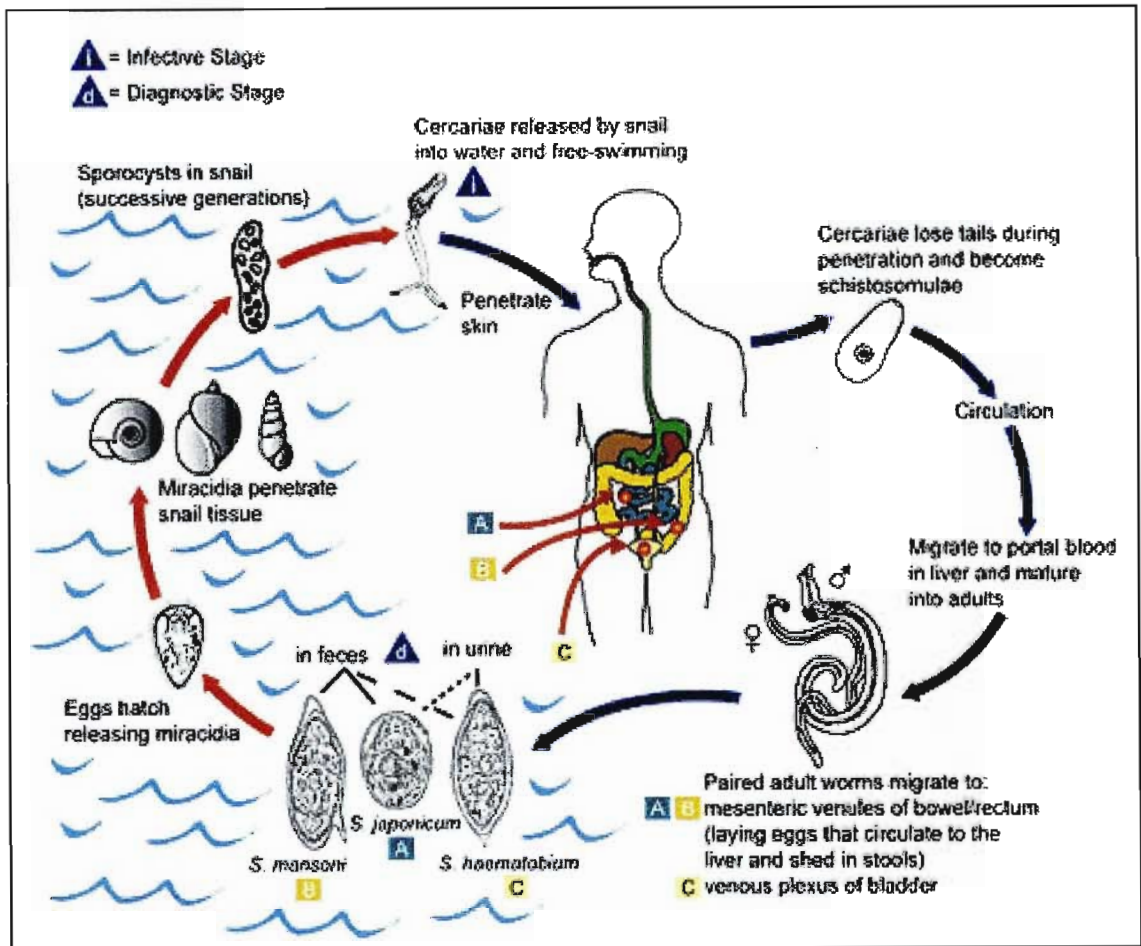


Figure 3.4 Life-cycle of *Schistosoma spp.* indicating various hosts at different stages of the cycle (Adapted from Centres for Disease Control and Prevention, 2006)

3.1.5 The role of canoeing and canoeists in the area

Canoeing in KwaZulu-Natal accounts for approximately half of the total population of canoeists in the country (Oliver, 2006). The biggest canoeing event in the country, the Dusi Canoe Marathon, is hosted annually in the Province. Partly as a result of the attraction of the event, and partly because it falls between the two largest cities in the province, the majority of canoeists cluster in and around the cities of Pietermaritzburg and Durban. Popular training venues along the rivers include Camps Drift (Pietermaritzburg), Shongweni Dam (on the Umlazi River), Albert Falls Dam, Midmar Dam, Nagle Dam, and Blue Lagoon (Durban).

Since the inception of the Dusi Canoe Marathon and canoeing clubs in the Province, the canoeing fraternity has taken an active interest in concerns of both community

development and environmental awareness. One of the earliest participants in the event, Dr Ian Player, was the founder of the internationally acclaimed Wilderness Leadership School and the WILD Institute, and has been a well known role-model and mentor for many of South Africa's conservation leaders. Dr Player is just one, albeit a prominent one, of many individual canoeists who have found their niche in environmental awareness programmes and organisations. Most recently, The Duzi-Umgeni Conservation Trust (DUCT) - was formed by local canoeists concerned with the state of the river. DUCT will be discussed in more detail later in this chapter.

The KwaZulu-Natal Canoe Union has been involved in the upliftment of communities in the valleys through which canoeing races take place. In support of this initiative, a portion of each paddler's annual affiliation fees and a portion of the monies from each race an individual enters are contributed to a development fund. In some cases, this amount is doubled rand for rand by major sponsors of canoeing events. In the past this fund was used to finance community development projects such as the building of classrooms and the establishment of river ferry crossings. In more recent years, however, this fund has been used to finance canoeing development initiatives in those schools, providing children of the communities with skills and opportunities they would otherwise be unlikely to experience. As a result of the projects, some of the paddlers from these initiatives have been awarded positions in national teams representing South Africa - positions based on merit, which they earned against other, more advantaged individuals.

Canoeists have a significant role to play in the identification of problem areas in the catchment, and are often instrumental in the persuasion of management bodies and organisations to take action. One such incident where the publicity created by canoeists was following the 1991 Dusi Canoe Marathon. High rainfall on the night preceding the race and again during the event itself resulted in a very full river, and many canoeists fell ill as a result of contamination of the water from overflowing sewers and drains. The event was the catalyst that secured the takeover by Umgeni Water (local water management body) of the local sewerage works at Darvil (Pietermaritzburg) and running this as a private enterprise. In addition, the capacity of the works was doubled and a

large storage dam constructed to contain excess fluid in times of high flows so that it could be stored and treated in due course as the flood subsided (Oliver, 2006).

3.1.6 Catchment Management and water-related legislation in South Africa

Management of water can be divided into two components; water resource management, and water supply services (Thompson et. al., 2001). The former refers to the management of water resources to fulfil both human requirement objectives, and ecological requirement objectives in such a way that the sustainable use of the resource is ensured. The latter refers to the management of the provision of water to people – for use in the domestic, agricultural and industrial extent. Neither component can be successfully managed in isolation from the other.

South Africa's new body of Water legislation, promulgated in the National Water Act (NWA), Act no. 38 of 1998, reflects this view of integrated management of water resources for ecological requirements as well as human supply requirements (Republic of South Africa, 1998). As a result of its integrated management and responsibility principles, and the recognition that an ecological Reserve needs to be established to ensure the environmental requirements, the NWA is viewed internationally as an example of progressive legislation towards which many nations strive (Lindqvist, 1998). Within South Africa, however, the Act has been criticised by some as being too much in favour of protecting the ecosystem at the expense of human needs (van Wyk et. al., 2006), and creating a 'vision' that is beyond the capabilities of a country struggling with numerous social and economic problems. This response is indicative of an ideology that does not recognise the links between the environment and humans, and demonstrates that society has much to learn before progress can be made. As discussed earlier (chapter two) the goods and services provided by water resources are reliant on the health of their ecosystems, and while South African water policy, and the NWA poses a significant challenge in its implementation (MacKay et. al., 2003), its outcomes will be of benefit both to ecosystems and humans.

The implementation of water policy in South Africa is three-tiered, and structured in such a way that, while ultimate custodianship of all water resources is mandated to national

government, responsibility and control is shared by all sectors of governing bodies and water users. The NWA proposes catchment management as the integrated management of all water resources in a catchment, with participation from all stakeholders representative of gender, race and communities, to obtain a balance in the utilisation and protection of water resources in a sustainable manner (DWAF, undated).

The first tier of management is the policy and regulation branch, which is mandated to the National Government, acting through the Minister and the Department of Water Affairs and Forestry (DWAF) (Republic of South Africa, 1998). Through the Act, the Ministry is responsible for leading the protection, use, development, conservation, management and control of the nation's water resources in a sustainable and equitable manner that is to the benefit of all people.

Secondly, the Act makes provision for the establishment and governing of Catchment Management Agencies (CMA's), which see to the regional or catchment level management of water resources. CMA's are concerned with the investigation and advice of water resources, and are further responsible for the development of a catchment management strategy. At the core of the CMA's function, is the role it plays in facilitating the balanced integration of all facets of water management, from the contributions made from the various sciences, to the needs and views of all stakeholders. The task is far from clear-cut, and there will be, as highlighted by Rogers et. al. (2000), much debate and discussion as to the manner in which the CMA's will operate in changing social environment. The task is a pioneering one, as it is not yet common practice in international water management and there is no standard format by which to assess progress.

There are nineteen identified Catchment Management Areas in the country, and the Msunduzi and Mngeni Rivers fall within the Mvoti to Umzimkulu CMA, which was established on the 20th May 2005. At the time of this dissertation, this CMA was still in the process of establishing a committee, with the result that very little has been achieved as set out in the NWA.

The third and largest tier of management and responsibility comprises the multitude of organisations and institutions, such as businesses, forums, industries, local authorities, water service providers and other interest groups operating at a local level (DWAF, 2004; Thomson et. al., 2001, Mackay et. al., 2003). These are often groups located within the area they choose to take responsibility for, and are driven by personal desire to change their environment for the better. Being physically close to the resource, and personally affected by its condition, this tier of management is often the key initiator of projects and in many instances has the most impact in management of the catchment.

The next section briefly discusses some of the relevant organisations operating in the Msunduzi/Mngeni catchments and how they impact on the management of the two rivers.

3.1.7 Local organisations involved in water management

3.1.7.1 Umgeni Water

Established in 1974 as a statutory Water Board, Umgeni Water (UW) was designated as the primary supplier of potable water to the cities of Pietermaritzburg and Durban. The organisation has since expanded to supply an area of over 21 000km² and a population of over seven million people (Nozaic et. al., 2001). UW has commissioned a number of large dams in the province to meet its supply needs. Each dam is surrounded by a nature reserve, which is managed by a subsidiary of Umgeni Water – Msinsi Holdings. Msinsi is responsible for managing the reserves and tourism projects associated with them.

In addition to water supply, Umgeni Water owns four local wastewater and sewerage works located at Darvil (Pietermaritzburg), Howick, Albert Falls and Ixopo. Darvil is also home to an extensive bird sanctuary.

3.1.7.2 Duzi-Umgeni Conservation Trust

The Duzi-Mngeni Conservation Trust (DUCT) is a non-profit, Section 21 organisation established by a group of interested parties – mostly canoeists – in support of the environmental health of the Msunduzi and Mngeni Rivers. Their aim is to lobby

government agencies to prioritise the environmental concerns of the two rivers, and provide management skills and human resources to assist those agencies, and ensure productive, positive action is taken. Included in their mission objectives, the organisation strives to improve the health of rivers for paddlers, other recreational users, farmers and local communities by focusing on eight areas of environmental concern:

- Solid waste (including plastic bags, bottles, tin cans, animal carcasses) that enters the river from a variety of sources including illegal dumping;
- Faecal waste from broken and blocked sewers and areas under-serviced;
- Industrial pollution;
- Invasive alien vegetation along the river banks;
- Invasive alien vegetation in the water (E.g. Water Hyacinth)
- Bilharzia and other water-related diseases
- Soil erosion and land degradation
- Provision of water for the environment (ecological Reserve)

The organisation is pro-actively involved in activities that educate communities about the benefits of clean river systems and how they can improve their living conditions by practising good sanitation and keeping their environment safe. Acting on this, in conjunction with World Clean-up Day on the 16th September 2006, DUCT launched the first River Clean-up Day with public participation. DUCT and *A Rocha* (discussed below) coordinated a waste clean-up along the rivers, involving the efforts of a total of 70 organisations, schools and companies in Pietermaritzburg and 12 in Howick. Two thousand volunteers collected approximately three thousand bags of litter and solid waste from the banks and riverbed (DUCT, 2006), which were then removed by the city's waste disposal services and taken to the properly registered dump site. Despite the immense success of the day, however, canoeists taking part in a canoe race through the city, held the following day were appalled at the horrendous quantity of litter and waste still floating in the river. The photograph (Figure 3.3) taken below the city section of river one month after the clean-up shows that considerably more effort will be required to make a noticeable impact on river waste along the Msunduzi.

3.1.7.3 *Msunduzi Catchment Management Forum*

The Msunduzi Catchment Management Forum is composed of various stakeholders in the water sector, including members from DUCT and other interested bodies, and employees of key organisations such as Umgeni Water, the Department of Water Affairs and Forestry and the local municipality. The forum creates an open discussion group through which concerns of the catchment can be raised and dealt with by people from different backgrounds, and with different skills, thus creating an integrated, active structure that establishes a link between government and municipal bodies and other stakeholders. The Forum meets quarterly to discuss matters and set deadlines for actions.

3.1.7.4 *A Rocha*

A Rocha is an international Christian organisation started in Portugal as a field study area and bird observatory. Since 1994, the organisation has spread throughout the world as a consortium of Christian people interested in the protection of wildlife and important habitats (A Rocha, 2006). In South Africa the organisation has centres in both Cape Town and Pietermaritzburg, where they work together with people, regardless of their choice of faith, but with a shared understanding of the importance of nature's plight, to provide opportunities for children and adults to learn about the country's natural heritage and contribute to its preservation. In Pietermaritzburg, *A Rocha* has aligned its efforts with those of DUCT to make a collaborative impact against river awareness and protection. Their partnership on the world clean-up day on the 16 September 2006 resulted in an effective pooling of resources and a greater achievement at the end of the day. It is an example of how similar bodies with similar interests can work together to make a more successful impact in bringing about environmental awareness and action.

CHAPTER FOUR

METHODS

4.1 Introduction

The methods employed in this study were twofold: Firstly, urine testing of canoeists for *Schistosoma haematobium* infection was conducted at a number of canoeing events between January and March 2006; secondly a questionnaire-based survey was undertaken, targeting canoeists who participated in the 2006 Dusi Canoe Marathon. The aim of the questionnaire was to determine the extent and nature of water-related illnesses contracted during the event as a result of heavy rainfall the night before the start, resulting in very high levels of *E.coli* in the river. In addition, the questionnaire was designed to ascertain paddlers' experience on previous Dusi marathons and diseases they may have contracted before this year's race. It was hoped this additional information would provide some insight into the broad perception of water quality in which the paddlers were competing and the various types of water-related disease pathogens that may be found in this section of river.

The research focused on using canoeists - as recreational and professional water users - as a starting point for determining firstly if there is a noticeable infection rate, and secondly, what types of disease are commonly contracted through contact with the water in the catchment. While the sample population was not representative of the communities that live along the river and use the water for domestic day-to-day use, canoeists are far more accessible for the needs and within the limitations of this research. It is likely that if the research demonstrated high incidence of water-related disease infection among canoeists, it could be assured that a far higher incidence would be found among community users, who have considerably more frequent and acute contact with the water. Canoeists will therefore be used as an index for assessing the Schistosomiasis situation in the catchment.

4.2 Study Area, population and test candidates

The study area falls within the Mngeni and Msunduzi River catchments, in the KwaZulu-Natal Province on the east coast of South Africa. The climate is predominantly tropical to sub-tropical, with mean annual air temperatures ranging between 20-26°C. Maximum daily temperatures in summer (November to February) can be very high, reaching more

than 40°C in the deep river valleys. Rainfall is predominantly during the hot summer months and is characterised by thunderstorms resulting in high peak flows and flood events (DWAF, 2001). The Mean Annual Precipitation (MAP) for the catchment is between 410-1 450mm (WRC, 2002).

The research catchment extends over a densely populated, highly developed area, where human activities and land-use range from heavy industry, intense agriculture and commerce to impoverished domestic communities and urban sprawl. A more detailed description of the catchment and problems associated with human use of the river resources is provided in Chapter three.

4.3 Ethical approval and correspondence

This research required ethical approval from the UKZN medical ethics committee. In order to obtain approval, an informed consent form was developed (Appendix A) to ensure that all participants were aware of the details of the research, who was responsible, and that as volunteers, they were free not to participate, or withdraw at any stage with no obligations. It also stated that the research would be anonymous, and that any personal information submitted would be used for individual communication to inform volunteers of their test results only.

Permission and approval was obtained from the various canoeing governing bodies, and event organisers. A letter (Appendix B) was written to each organisation informing them of the intent of the research, and what would be required of them. In addition, the research was advertised on the local canoeing newsgroup email informing canoeists of the details of when and where they might take part. Table 4.1 indicates the various activities that were completed before sampling commenced.

Table 4.1 Actions to be taken prior to sampling

| Action | Organisation concerned | Contact | Requirements/ Medium |
|-------------------|---|---|--|
| Ethical clearance | UKZN Ethics committee | Ms Phumelele Ximba (Research Office, UKZN) | Proposal and informed consent form |
| Canoeing Approval | KwaZulu-Natal Canoe Union Dusi Organising Committee Other race organisers | Sheila Whitfield (secretary) Cameron MacKenzie (Chairperson) | Proposal |
| Inform Canoeists | Individuals | | Advertisement informing paddlers of the intent of the research and inviting them to take part. |

4.4 Data Collection/Sampling

4.4.1 Schistosomiasis sampling

The most common strain of Schistosome in the province is *S. haematobium* – which causes urinary schistosomiasis (Saathoff et. al., 2004; Jinabhai et. al., 2001, Taylor et. al., 2004). Positive diagnosis of *S. haematobium* is confirmed by the presence of eggs in the urine sample. *Schistosoma mansoni* – which causes intestinal Schistosomiasis is also present in this province, but to a far lesser degree. Infection with this strain is identified through the presence of eggs in the faeces. Due to ease of testing and time constraints, and as it is the most common, only the *S. haematobium* strain was tested.

Urine samples were collected from volunteer canoeists at a number of canoeing events in the KwaZulu-Natal Province (January - March 2006). Canoeists were informed of the research and invited to take part via the formal weekly email newsletter, which is circulated to all canoeists registered in the province.

Canoeing events are held throughout the province and country, and not limited to specific areas. As a result, it was not necessary to test at specific venues, but rather ascertain, through questionnaires, where individual paddlers train regularly and which rivers they race on most often. With this in mind, testing venues/events were selected based on their popularity and the number of paddlers they were likely to attract, not on their geographical location. A number of events and venues were selected across the province throughout January thru March 2006. These are listed in

Table 4.2, with the date on which they occurred and the number of samples that were

| Date | Event/Place | No. of samples |
|---|---|----------------|
| 18 January | Dusi Registration - Camps Drift, Pietermaritzburg | 76 |
| 28 January | Schools Slalom - Estcourt | 44 |
| 04 February | Stihl Non-Stop Dusi - Blue Lagoon, Durban | 24 |
| 12 February | Umkomaas marathon - Richmond | 70 |
| 23 February | College School - Pietermaritzburg | 13 |
| 25 February | Drakensberg Challenge Day 1 - Underberg | 102 |
| 26 February | Drakensberg Challenge Day 2 - Underberg | 24 |
| 01 March | Lembethe Canoe Club - Nagle Dam | 26 |
| 02 March | Epworth Girls School - Pietermaritzburg | 10 |
| 04 March | Interschools event - Midmar | 9 |
| 05 March | Upper Umgeni Race | 39 |
| 08 March | Natal Canoe club members | 4 |
| 09 March | Kingfisher Canoe Club - Durban | 19 |
| *Other | Pietermaritzburg | 7 |
| TOTAL | | 466 |
| * Additional samples submitted by volunteers who could not attend the designated events, but wished to take part in the research. | | |

taken. While sampling was done on human subjects, the procedure was unobtrusive and did not require a registered medical practitioner to be present.

Table 4.2 Dates, venues and number of samples collected

| Date | Event/Place | No. of samples |
|---|---|----------------|
| 18 January | Dusi Registration – Camps Drift, Pietermaritzburg | 76 |
| 28 January | Schools Slalom - Estcourt | 44 |
| 04 February | Stihl Non-Stop Dusi – Blue Lagoon, Durban | 24 |
| 12 February | Umkomaas marathon - Richmond | 70 |
| 23 February | College School – Pietermaritzburg | 13 |
| 25 February | Drakensberg Challenge Day 1 - Underberg | 102 |
| 26 February | Drakensberg Challenge Day 2 - Underberg | 24 |
| 01 March | Lembethe Canoe Club – Nagle Dam | 26 |
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| 09 March | Kingfisher Canoe Club - Durban | 19 |
| *Other | Pietermaritzburg | 7 |
| TOTAL | | 466 |
| * Additional samples submitted by volunteers who could not attend the designated events, but wished to take part in the research. | | |

The adult *Schistosoma* are most actively laying eggs between 10h00 and 14h00 in the day. To accommodate for this, urine samples were only given within this time span. Volunteers were provided with numbered 500ml plastic sampling jars, questionnaires and Informed Consent Forms. They were asked to first fill in the forms and then provide total bladder contents. At the end of each sampling day, each sample was split into two 10ml samples and preserved with 5ml Merthiolate/formalin complex. Samples were examined using a standard centrifugation and sedimentation method to determine the presence of *Schistosoma haematobium* eggs.

The questionnaires and signed Informed Consent Forms were retained and all information was entered into an Excel spreadsheet for analysis.

In order to establish how the trends in Schistosomiasis infection have changed over the past decade, a comparison of results was made against a previous study (Appleton and Bailey, 1990).

4.4.2 Dusi Canoe Marathon illness

During the weeks following the 2006 Dusi Canoe Marathon, a questionnaire (Appendix C) was sent electronically to all canoeists who took part in the 2006 event and had provided email addresses on their Canoeing South Africa registration forms ($N= 1732$). Two weeks after the initial email, the questionnaire was sent again to all those who had not responded, and a blanket message was posted on the KNCU website and sent on the weekly newsletter via email to all registered canoeists in the province. Negative responses (i.e. from those who did not suffer any illness) were specifically requested, as people are often more inclined to respond if they are affected. It was hoped this would increase the overall number of responses and lessen the bias.

The questionnaire-based survey method was used as it was considered the most effective method of including the highest number of participants from the event. Ideally, a test of illness associated directly with the event would warrant the physical testing of canoeists immediately after the event, but this process was neither within the budget, nor logistically possible, within the time and resource constraints of this dissertation.

This questionnaire sought to determine how many paddlers experienced illness associated with the quality of the river water during and immediately after the event. Questions relating to the respondent's Dusi Marathon paddling history, their ability (number of times they swam during the event), and whether or not they had contracted any water-related illnesses. This section enquired as to the nature, diagnosis and treatment of the illness, and asked whether they had experienced illness on previous Dusi Canoe Marathons.

Responses were received over two months from the first date the emails were sent out. Once all responses were collected, the data were compiled in a spreadsheet, and the raw data (responses) were stored digitally. As the data was mostly qualitative, there was a lengthy period of data sorting to establish a useable format.

In addition to the information received from canoeists, water quality data were obtained from Umgeni Water. Data included *E.coli* readings taken as part of routine monitoring in and around Pietermaritzburg, during the weeks prior to the event and after the event, and additional readings taken at various locations along the entire course of the race, while the event was in progress.

4.4.3 Pietermaritzburg survey

As a precursor to this research, a questionnaire was circulated among canoeists in the Pietermaritzburg and Hilton area of the catchment. The questionnaire related to general illness contracted as a result of training and racing on the Msunduzi River. The data was included in this research, as the majority of the paddlers who took part in this survey did not take part in the actual 2006 survey.

4.5 Assumptions and Limitations

There were a number of limitations and assumptions identified during the research process. These are listed for both the Schistosomiasis testing and Dusi Illness Survey below.

4.5.1 Bilharzia testing

Limitations:

1. Possibly the greatest limitation with the Bilharzia sampling was the hours between which it was viable to take the samples. As it is understood (Appleton, pers. comm., 2006) effective sampling can only take place between the hours of 10:00 and 14:00, as this is when the *Schistosomes* are active. Had it been possible to take samples in the early evening for example, sampling stations could have been set up at all the weekly time-trials in Pietermaritzburg and Durban and a far greater number of paddlers would have participated. As it was, many of the events started earlier in the morning than the allotted sampling time, and the majority of participants finished the race after the 14:00 cut-off. As a result the sample size was not as large as originally anticipated.

2. It became apparent at the outset of the testing, that there was some resistance to the sampling by some volunteers as they felt embarrassed by the procedure. As a result some potential volunteers avoided the information table at race event.

Assumptions:

1. It was assumed that *S. haematobium* is the most common strain of *Schistosoma* in this province. Testing for the other strain found in South Africa, *S. mansoni*, which locates itself in the intestines, is tested using faeces and cannot be diagnosed by the methods used in this research.

4.5.2 Dusi Canoe Marathon illness survey

Limitations:

1. The decision to distribute the questionnaire via email was made on the basis that the majority of canoeists operate with email as their primary form of communication with the KwaZulu-Natal Canoe Union. This would ensure the questionnaire was received timeously after the event and could include international participants more easily. This did, however result in the region of 500 paddlers not receiving the questionnaire as a combination of both no email address given, and incorrect or barred email.
2. The questionnaire was qualitative in nature, with answers that were, for the most part, non-numerical and therefore difficult to quantify. In addition, respondents were inclined to provide additional information beyond what the question asked for, resulting in a lengthy process of sifting through data to establish a useable database. While this was a lengthy process, it provided valuable and interesting additional information, making the canoeing resource base an exceptional source of data that may not have been accessible had a different community been used for this research. The canoeists proved not only to be interested in the outcomes of the project, but enthusiastic to contribute wherever they could to enhance the quality and depth of the research.

CHAPTER FIVE

RESULTS AND DISCUSSION

This chapter gives an interpretation of the results of the research and discusses their significance. The Schistosomiasis testing is considered first, with a look at statistics and then a comparison with previous research in the same area. Secondly, the results of the Dusi Canoe Marathon survey are consulted and their implications reviewed.

5.1 *Schistosomiasis Testing*

A total of 466 urine samples were analysed, and the prevalence of *Schistosomiasis haematobium* was recorded to be 4.30% (20/466). The level of infection ranged from very light (1eggper10ml sample) to severe (486eggs per10ml), with the heaviest infections from Nagle Dam. Regionally, there were 14 infected individuals from KwaZulu-Natal, 8 of which were from Nagle Dam. The remaining 4 cases were based in Gauteng, and have the Klip River as their common training and racing venue. Six of the infected people reported having been tested previously, and all except one tested positive on those occasions and were treated with Praziquantel. None of the infected people had taken Praziquantel prophylactically in the past.

5.1.1 *Schistosomiasis questionnaire*

The results of the questionnaire filled in by all volunteers in the Schistosomiasis sampling revealed additional information about the status of the disease among canoeists. Significantly the total number of people taking part in the survey that have been tested prior to this occasion indicates the number of people that could potentially be infected at any one time. A total of 211 people reported having been tested on previous occasions, of which 153 (72.51%) were positive (Table 5.1). Thus, while only 4% of individuals tested during this survey were positive, 73% of all those who participated have been infected with Schistosomiasis and treated with Praziquantel at some stage during their canoeing career. Forty-two (8.55%) of all respondents have, in the past, taken Praziquantel as a prophylactic to reduce the chances of *Schistosoma* infection.

Table 5.1 Summary of Schistosomiasis respondent questionnaire results

| Schistosomiasis sampling (<i>n</i> =466) | No | % |
|---|-----|-------|
| No. of respondents tested in 2006 | 466 | |
| Positive | 20 | 4.30 |
| Negative | 446 | 95.71 |
| No. of respondents tested prior to 2006 | 211 | |
| Positive | 153 | 72.51 |
| Negative | 58 | 27.49 |
| Number who have taken Praziquantel without being tested | 42 | 9.01 |

5.1.2 Regional infection rates

As canoeists from all over the country took part in this investigation, it is possible to make some inferences about regional infection rates and some speculation as to the possibility of infection at specific training venues.

Figure 5.1 illustrates the percentage of canoeists who have been tested previously from each training venue included in the survey, and the percentage who tested positively on those previous tests. Areas of 100 % positive infection of those paddlers who have been tested previously include: Sandvlei, Germiston Lake, the Klip River, Chrystal Springs Dam, Wemmer Pan, Florida Lake and Johannesburg in Gauteng; Nagle Dam, the Upper Umgeni, Albert Falls and Umhlali Farm Dam in KwaZulu Natal, and the Nahoon River in the Eastern Cape; Pennisula Canoe Club in Cape Town in the Western Cape and the Orange River in the Free State.

As this dissertation focused on the Msunduzi and Mngeni rivers, training venues for these areas were singled out. The percentage of respondents who had received a positive test result in the past was extracted from the data, and is illustrated in Figure 5.2. The percentage of respondents who take Praziquantel intermittently as a prophylactic was also included.

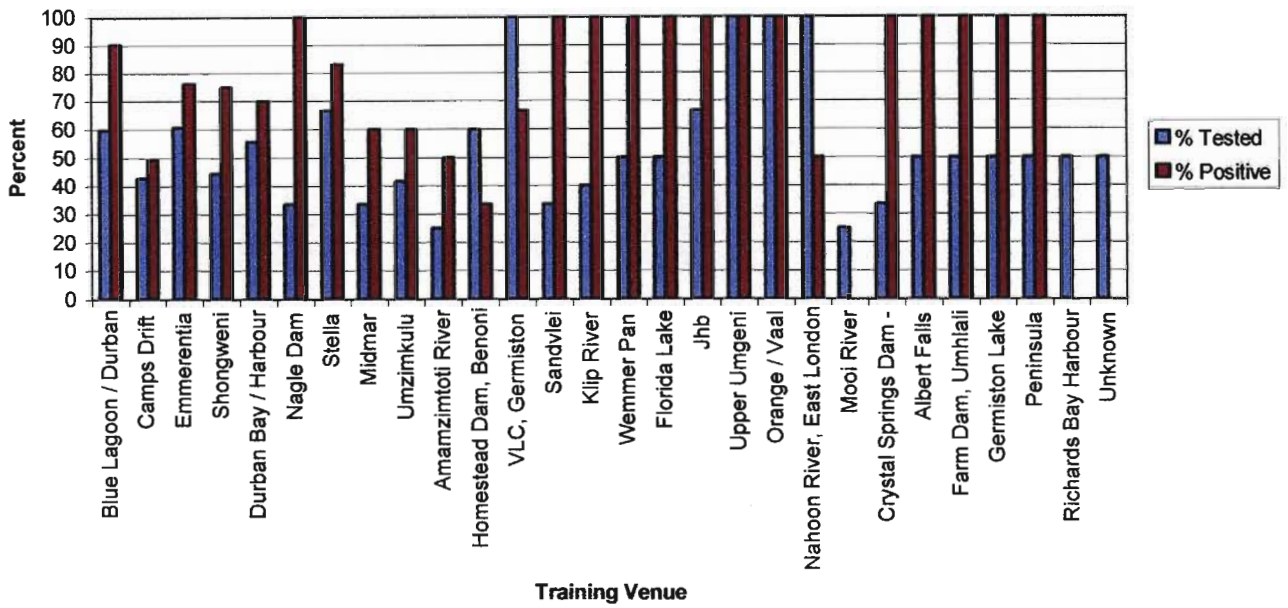


Figure 5.1 Previous testing for *Schistosoma haematobium* infection, showing percentage of positive results by training venue

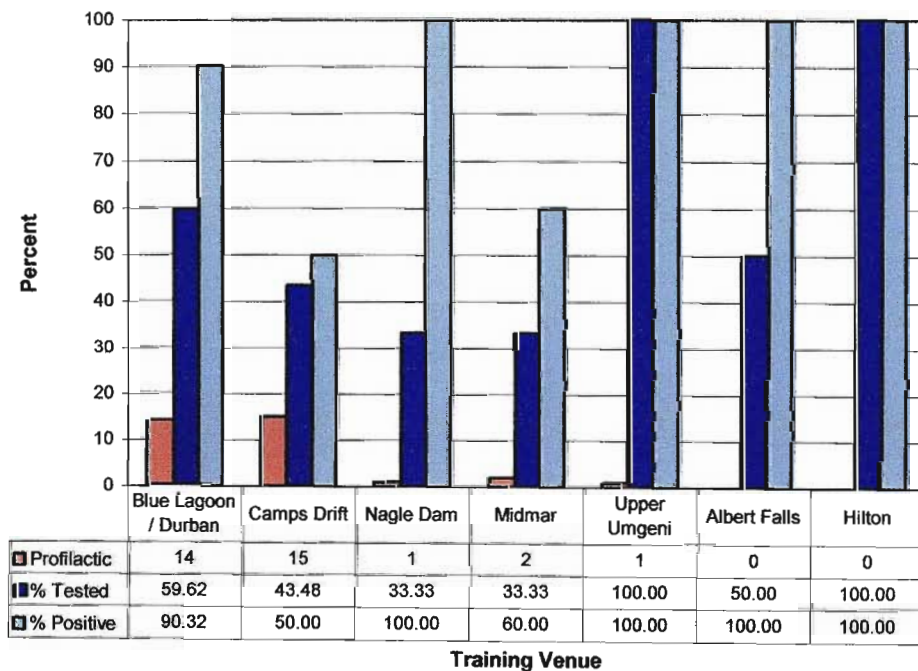


Figure 5.2 Previous *Schistosoma haematobium* infection statistics from respondents training on the Msunduzi and Mngeni rivers (sub-sample of Figure 5.1)

The results indicate that paddlers from all training venues along the Mngeni and Msunduzi Rivers are at risk of contracting Schistosomiasis. While paddlers may move from venue to venue from time to time and there is the possibility that infection may have occurred at a different venue, it was assumed that the majority of paddlers train predominantly in a particular venue. Those training at Hilton, Albert Falls, Upper Umgeni (which is the area immediately below Albert Falls Dam) and Nagle Dam, are at particularly high risk as 100% of those individuals who tested previously have had a positive result.

5.1.3 Nagle Dam testing

The Nagle Dam participants, who are Zulu, rural-dwelling people, constituted a large number of positive cases in this survey. These participants live in the Mngeni River Valley and use the river daily for domestic activities and for swimming and recreation. As a sub-sample, these canoeists are far more representative of the local communities living in the Mngeni valley, who also use the resource daily and are dependant on it - placing them at higher risk of infection than those canoeists who only use the rivers for recreation and sport. The facilities and services available to these communities are limited, making their options for treatment and education on remediation methods poor.

A summary of all of the Nagle Dam participants' responses is included in Table 5.3. The results show that of the 26 participants who were tested, 38.46% (10) were schistosomiasis positive (Table 5.2). Answers provided in the respondent questionnaire (Table 5.3) reveal further insights as to the status of Schistosomiasis in the Nagle Dam area in the past. The respondents ranged in age from 9 to 29 years, and only one respondent was female. Fourteen respondents have competed in the Dusi Canoe Marathon, while some have not paddled in venues outside of the Nagle Dam area. There is no trend in the infection rate of those who have paddled the Dusi Marathon and those who have not. This information is important as it suggests that infection is not related to age. It also confirms that Schistosomiasis is present in this area, as some of the paddlers have never paddled on other rivers or in other areas, which is the case with many of the previously mentioned training venues.

Of the 26 participants, 9 indicated that they have been tested and treated for Schistosoma infections prior to this research. While it was assumed, at the outset of this research, that this group of participants would not have been tested previously due to lack of funding and medical services, it was established that this was not the case. Through discussion with the participants, it was revealed that there are community/school clinics that test and treat school children in the area from time to time. There is, however, no long-term programme to combat the disease.

All 9 (100%) of the previously tested participants were positive on their previous result and were treated accordingly. If we assume that each test is an individual event, there have been 35 test cases in total (26 tests in 2006 + 9 previous test cases). Of these a total of 10 people have never tested positive, while 19 tests have been positive for Schistosoma infection. This indicates that 54.29% (19/35) of all test cases have been positive.

Table 5.2 Summary of results of Nagle Dam Schistosomiasis test

| | Number of participants | Number of positive respondents | Percent positive |
|-------------------------------|------------------------|--------------------------------|------------------|
| Tested in 2006 | 26 | 10 | 38.46% |
| Tested and treated previously | 9 | 9 | 100% |

In some cases the egg count in the 10ml urine samples was extremely high (Table 5.3). The numbers in the column headed 'Eggs' indicates the average number of eggs from the two 10ml urine samples tested per individual participant. There is also a discrepancy between those who have been treated previously and those who were tested for the first time through this research. Those who have been treated in the past have far lower egg counts than those testing positive for the first time. This could suggest treatment at some stage is effective, even if reinfection should occur after a period of time.

None of the Nagle Dam participants filled in the section of the questionnaire enquiring about water-related disease that they may have contracted on previous occasions. This could be due to lack of understanding of illnesses and how they may have come to be infected with them. Many of these people come from disadvantaged backgrounds, where education and health have been neglected. This group is representative of many of the

non-canoeing communities living in the Mngeni Valley and their participation in this research is a starting point for understanding the dynamics of Schistosomiasis within those communities.

Table 5.3 Summary of questionnaire of individuals from Nagle Dam tested positive for *Schistosoma haematobium* infection (N = 26)

| Positive in 2006 | Eggs per 10ml | Test No. | Date of Birth | Age | Sex | Years Active | Trained | No. of Dusi's | Tested before | Years | Positive/Negative | Treated |
|------------------|---------------|----------|---------------|-----|-----|--------------|---------|---------------|---------------|--------------|-------------------|-----------|
| Yes | 8 | 394 | 8/30/89 | 17 | M | 4 | Daily | 2 | Yes | 1999 | Pos | Yes |
| | | 397 | 4/24/92 | 14 | M | 1 | Daily | | Yes | 1999 | Pos | Yes |
| Yes | 6 | 398 | 13/1994 | 12 | M | 2 | Daily | | Yes | 2002 | Pos | Yes |
| | | 399 | 28/1993 | 12 | M | 2 | Daily | | Yes | 2002 | Pos | Yes |
| | | 407 | 6/6/83 | 22 | M | 9 | Daily | 4 | Yes | 1996 | Pos | Yes |
| | | 411 | 5/31/87 | 19 | M | 7 | Daily | 4 | Yes | 1999 | Pos | Yes |
| | | 412 | 4/6/91 | 15 | M | 7 | Daily | 0 | Yes | 2002 | Pos | Yes |
| Yes | 4 | 413 | 25/1994 | 12 | M | 1 | Daily | 0 | Yes | 2004 | Pos | Yes |
| Yes | 11 | 415 | 11/21/89 | 17 | M | 4 | Daily | 2 | Yes | 2001 2004 | Neg Pos | No Yes |
| | | 45 | 6/1/76 | 29 | F | 5 | Daily | | No | | | |
| | | 395 | 9/1/89 | 17 | M | 7 | Daily | 1 | No | | | |
| | | 400 | 10/26/83 | 22 | M | 9 | Daily | 5 | No | | | |
| | | 401 | 3/23/85 | 21 | M | 6 | Daily | 3 | No | | | |
| | | 402 | 3/1/85 | 21 | M | 8 | Daily | 5 | No | | | |
| | | 404 | 8/21/90 | 16 | M | 1 | Daily | 1 | No | | | |
| | | 406 | 12/27/89 | 17 | M | 5 | Daily | 1 | No | | | |
| | | 408 | 1/7/89 | 21 | M | 9 | Daily | 6 | No | | | |
| | | 409 | 8/11/91 | 15 | M | 4 | Daily | 0 | No | | | |
| | | 410 | 6/30/06 | | M | 9 | daily | 6 | No | | | |
| Yes | 23 | 414 | 12/22/87 | 19 | M | 3 | Daily | 2 | No | | | |
| | | 416 | 7/8/89 | 17 | M | 9 | Daily | 2 | No | | | |
| Yes | 36 | 417 | 1/23/92 | 14 | M | 1 | Daily | 0 | No | | | |
| Yes | 482 | 418 | 12/1/92 | 14 | M | 2 | | 0 | No | | | |
| Yes | 486 | 419 | 6/16/05 | 11 | M | 2 | | | No | | | |
| Yes | 75 | 39 | 2/4/80 | | M | 4 | Daily | | No | | | |
| Yes | 203 | 420 | 10/1/97 | 10 | M | 2 | | | No | | | |
| 10 | | | | | | | | | 9 | | | |

5.1.4 Previous trends

In comparison with a previous study on the prevalence of *Schistosoma haematobium* among canoeists (Appleton and Bailey, 1990), this survey indicates a considerably higher infection rate. The previous study revealed an infection rate of 1.8% in 1988, and a 0% infection rate in 1989, compared with this study's result of 4.07% (Table 5.4).

Table 5.4 Summary of a comparison between this survey and a previous *Schistosoma haematobium* study (Appleton and Bailey, 1990)

| | 1988 | | 1989 | | 2006 | |
|--|------|------|------|----|------|------|
| | No. | % | No. | % | No. | % |
| Total number tested: | 330 | | 170 | | 466 | |
| Positive: | 6 | 1.82 | 0 | 0 | 20 | 4.30 |
| No. of respondents to the Questionnaire: | 33 | | 226 | | 466 | |
| No. of respondents taking Praziquantel prophylactically: | 17 | 52 | 78 | 35 | 42 | 9 |

Reasons for the increase in the infection rate could be the result of a number of factors, ranging from changes in the distribution of the intermediate host snail – *Bulinus africanus* – to changes in the population dynamics and migration of people to new areas. A recent snail survey conducted in the Pietermaritzburg area (Johnson and Appleton, 2005) indicated that *B. africanus* are present in the area and some are infected with the *Schistosoma* pathogen. In addition to the *B. africanus*, there was evidence of the *S. mansoni* host snail - *Biomphalaria pfeifferi*, although to a considerably smaller extent. This reveals that there is substantial scope for the presence of *S. haematobium* in the Pietermaritzburg, and therefore the Msunduzi area. At the same time, while there were considerably fewer of the *B. pfeifferi* individuals present, a higher percentage were infected with Schistosomiasis. This may indicate that while the opportunity for infection with *S. haematobium* may be much higher, there is the possibility of infection with *S. mansoni*, and this should not be overlooked in future studies in this catchment. There is evidence (Taylor et. al., 2004) that the *S. mansoni* strain is more prevalent in other parts of the province, and with the movement of people from one community to another, it is likely to spread in the future, provided the host snails are present. As pointed out by Johnson and Appleton (2005), the migration of large numbers of people into the urban fringe results in an increase in the opportunity for the establishment of diseases in new areas. Schistosomiasis may be easily spread by infected individuals migrating into the catchment and living in areas with poor sanitation. In addition, in the months following the sampling for this research, two of the respondents informed the researcher that they had tested positive for *S. mansoni* infection a few months after participating in this survey and testing negative for *S. haematobium*.

Changes in the dynamics of population, education and awareness and in the popularity of canoeing could also play an important role in the higher positive results revealed in this survey. The substantial development of communities living in the catchment of the Msunduzi River plays a part in the spread of Schistosomiasis. Over-burdening of the resource and lack of adequate sanitation services results in the pollution of the river with both solid waste - leading to degradation of habitats and water quality, and the contamination of the river with raw sewerage, which directly contributes to the Schistosomiasis problem.

The results of the comparison between this and the 1988/89 study (Appleton and Bailey, 1990) demonstrate a marked shift in the behaviour of paddlers, with only 8.55% of respondents taking anti-schistosomal drugs in 2006, compared with 52% and 35% in 1988 and 1989 respectively. This change could contribute to the higher rate of infection in this study. Saathof, et. al. (2004), in a study of the patterns of *Schistosoma haematobium* infection in rural schoolchildren in KwaZulu-Natal, show that re-infection with Schistosomiasis after treatment with Praziquantel is not significant within the first 41 weeks after treatment. After this time lapse, however, the re-infection rate increased substantially. These figures indicate that if infected paddlers - and local communities - are not being tested and taking the medication within this time frame, they could be exacerbating their own infection and contributing to the spread of the pathogen. Further studies that include treatment and retesting of participants could further substantiate this.

5.2 *Dusi Illness Survey Results*

The results of the Dusi Marathon survey can be divided into the following areas of concern:

1. The number of people who contracted some illness or ailment as a result of taking part in the 2006 Dusi Canoe Marathon and whilst training on the Msunduzi and Mgeni Rivers, and a breakdown of the different illnesses.
2. The relationship or lag between illness contracted and the time the participant first started to notice illness, as well as the duration of illness
3. An analysis of the behaviour/reaction of paddlers - number who visited the doctor, took medication, were hospitalised or who waited out the ailment.
4. Influence of water quality on incidences and timing of illness.

The Dusi questionnaire was emailed to 1732 of the Dusi Canoe Marathon 2006 entrants (all those who gave email addresses on their registration for the event). Two thousand and eleven individuals entered the event in either K1's or K2's. A total of 941 (54%) responses were received and analysed.

5.2.1 **Reported illness**

Of the respondents, 588 (63%) reported experiencing water-related illness in some form or other as a result of taking part in the marathon. Conversely, three hundred and fifty-two (37%) did not experience any illness (Figure 5.3). As some people experienced more than one ailment simultaneously, each infection was calculated as a separate case, with a result of 1004 cases reported. The most prevalent illness reported was diarrhoea, (504 cases, 51%) (Figure 5.4). The second highest figure was for nausea and vomiting - (263 cases, 26%). Infected wounds (11%), and the remaining 12% constituted a number of other illnesses. The 'other' illness category is illustrated in Figure 5.5, and includes cases of: tick bite fever (8), encephalitis (2), stomach cramps (23), weakness and loss of appetite (9), aching muscles (6), cold/flu or respiratory problems (23), ear infections (20), boils (4), sores or rashes (12), dehydration (3), eye infections (5), fever (14), hepatitis (2) and headaches (8). Alarmingly a case of typhoid was reported. Respondents attributed all

reported illnesses to contact with water while participating in the event. A summary of the breakdown of illnesses reported from the 2006 Dusi Canoe Marathon survey can be viewed in 5.8 (pg. 91).

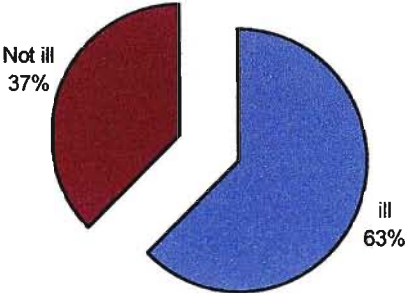


Figure 5.3 Percentage of ill vs. not-ill participants in the 2006 Dusi Canoe Marathon

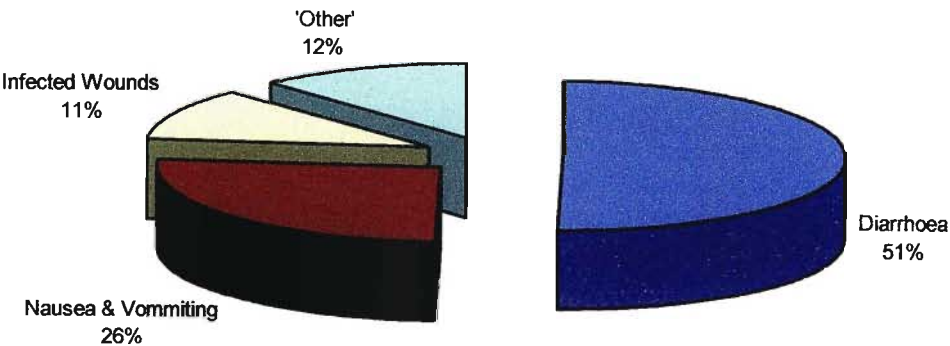


Figure 5.4 Breakdown of reported illness categories

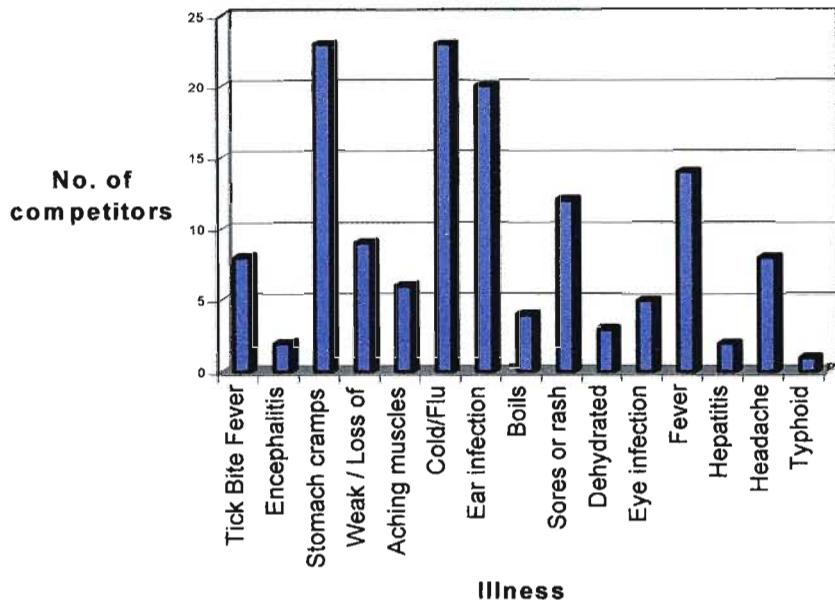


Figure 5.5 Histogram showing the division of 'other' illnesses experienced by competitors taking part in the 2006 Dusi Canoe Marathon

5.2.2 Impact of race experience

This information was requested to determine whether there was a correlation between the number of Dusi marathons completed and the number of reported illnesses. The results were hoped to determine whether having more Dusi experience, and therefore more exposure to the river water over a period of years, would influence a paddler's chances of becoming ill. Using the number of Dusi Marathons completed as the independent variable, and the number of paddlers (both those who reported ill, and those who did not report ill) as the dependant variable, a percentile trend was calculated (Figure 5.6).

The linear percentile indicates that there is evidence that those who have completed more marathons have as much as 20% less chance of being ill. The percentage indicates that the trend decreases from approximately 65% ill in the first year of racing, to 40% in those who have completed more than 30 Dusi Canoe Marathons.

Initially it was assumed that the reasons for this decline in the illness rate with increasing experience was due to paddlers capsizing less and therefore being exposed to full contact with the water fewer times. However, an analysis of the rate of illness per number of

swims (Figure 5.7) indicates that there is only a marginal increase in the percentage of ill participants with the increasing number of swims. While the number of swims may contribute to contracting infection to a small degree, it is not a substantial enough amount to account for the 20% difference in decline of illness with increasing experience. A possible reason might be that more experienced paddlers, who have experienced illness in previous events, are more inclined to actively avoid swallowing water and take more precautions to avoid becoming ill. It is not known whether paddlers develop an immunity to pathogens in the water, although it seems unlikely given that there is still a large proportion of very experienced paddlers who still get ill.

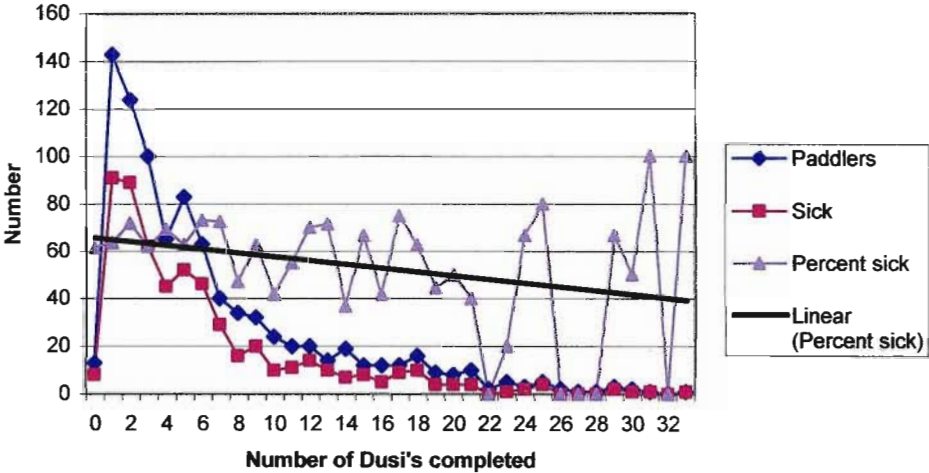


Figure 5.6 Quantity of completed marathons vs. incidence of illness

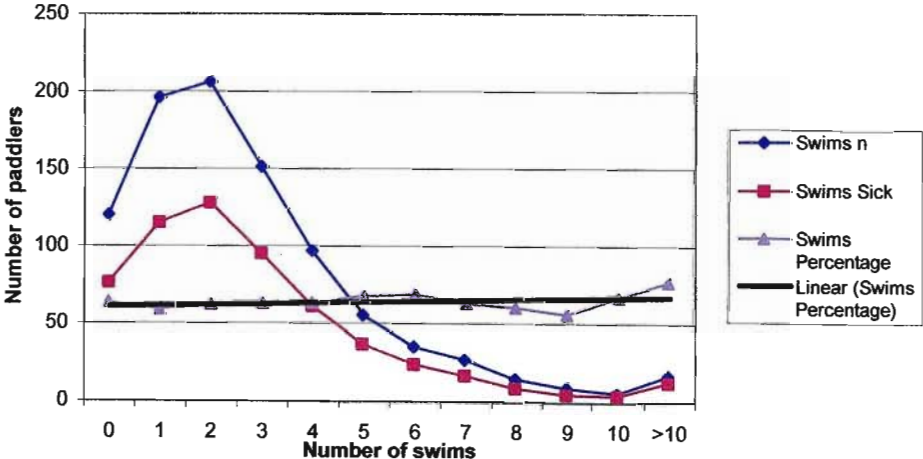


Figure 5.7 Number of swims vs. number of paddlers contracting illness

5.2.3 Burden of illness on canoeists and canoeing events

This section looks at the impact of illness on canoeists as individuals, and at the burden on both their livelihoods, and that of the canoeing fraternity and its subsidiaries.

The initial onset and duration of illnesses contracted during the 2006 marathon was calculated using the responses to the questions: 'When did you first start to feel/notice infection?' and 'How long did it last?' Figure 5.8 illustrates the breakdown of respondents initial onset of illness. For ease of analysis, the categories were broken down as follows:

Before Dusi = any water-related illness reported in the weeks leading up to the event as a result of tripping or pre-Dusi races.

Day 1 = From the start of the race at Camps Drift in Pietermaritzburg, to the start of Day 2 the following morning.

Day 2 = From the race start of day 2 at Dusi Bridge to the start of day 3

Day 3 = From the race start of day 3 at Inanda dam until the early hours of Sunday morning.

Day after = Any time on Sunday following the race.

After Dusi = Any symptoms only experienced in the days, weeks after the race

Unspecified

The data indicates that the majority (154 or 26%) of respondents first experienced symptoms on the second day of racing. The second highest number fell ill on day 3 (116), closely followed by the day after the finish of the race (103: 18%), and those who fell ill in the days and weeks following the race (101: 17%). Some respondents indicated that they fell ill before the Dusi, and attributed their illness to 'tripping' and training on the river in the weeks leading up to the event; these constituted the smallest group. A small portion of the field (38: 7%) fell ill after only the first day's racing. A high portion of respondents (71: 12%) did not respond to the question.

The responses to the second question were divided into the following categories – as indicated in Figure 5.9:

Table 5.5 Categories used to indicate the divisions in the length of illness

| Category | No. of days ill |
|----------|-----------------|
| 1 | 0-1 days ill |
| 2 | 2-3 days ill |
| 3 | 4-5 days ill |
| 4 | 1 week ill |
| 5 | 1-2 weeks ill |
| 6 | >2 weeks ill |
| ? | No answer |

Category 3 days had the highest number of cases (160), with the 1 week category having the second highest count with 102 cases. 1-2 days recorded the third highest with 83 cases, and less than one day recorded 68 cases. The least number of respondents were sick for 1-2 weeks, however those who were ill for a duration of more than 2 weeks was far greater at 76 cases. One respondent did not provide an indication of how long s/he was ill. From these results we can infer that the average infection incubation time was one to two days and lasted an average of four to five days.

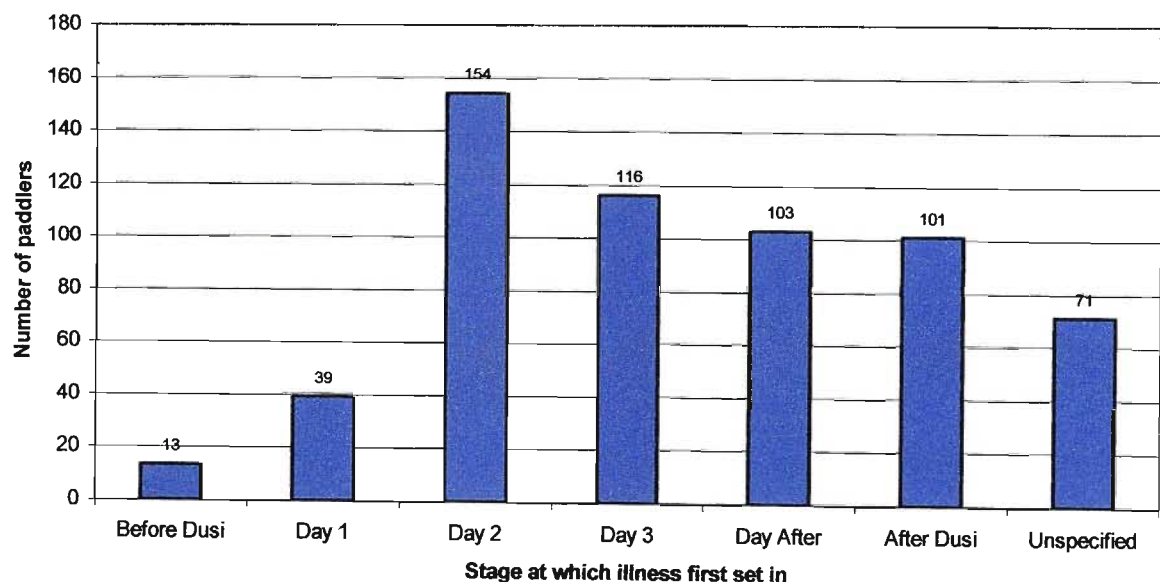


Figure 5.8 Onset of illness

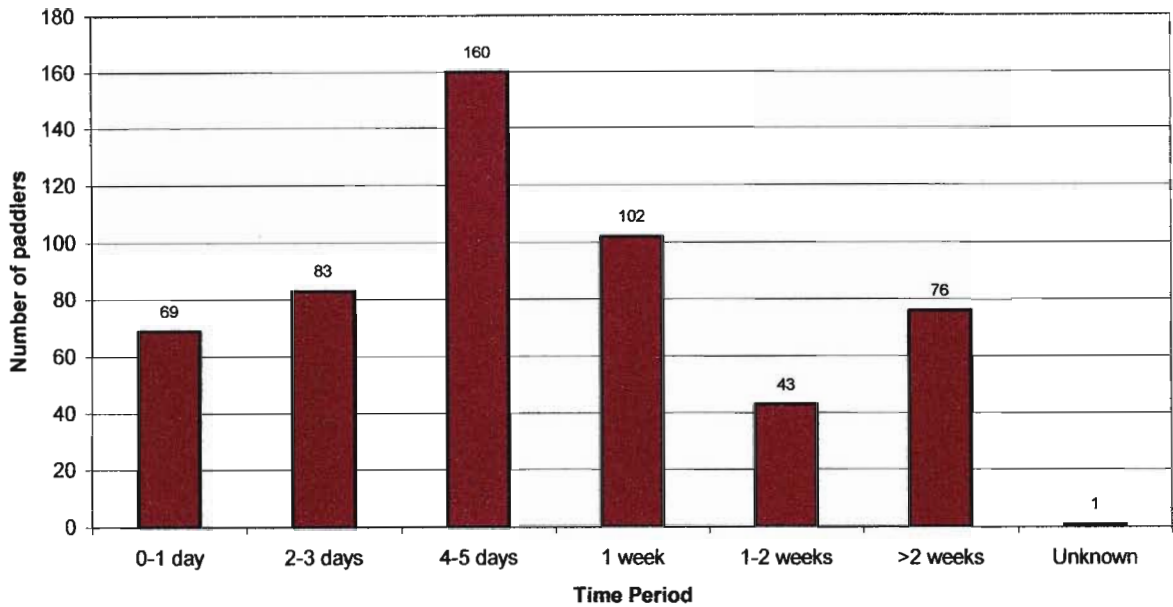


Figure 5.9 Duration of illness experienced by paddlers during and after the 2006 Dusi Marathon

Illness in any form is debilitating, and impacts negatively on an individual’s capacity to work and function normally. The financial cost of contracting an illness is also a burden on the individual, and reflects negatively on the race – which is costly in itself. Monetary costs include doctor visitation, medication, tests (for example, blood tests) to determine the disease pathogen, and in some cases hospitalisation.

The 2006 Dusi Canoe Marathon resulted in 215 individuals consulting a doctor, 357 people purchasing medication, with many of those reportedly having to take more than one course of medication before any obvious effect was achieved. The breakdown of medications taken is shown in Table5.6.

Table5.6 Medical treatment and costs sought by participants in the 2006 Dusi Canoe Marathon

| Burden | Dusi 2006 | Cost per unit (R) | Total (R) |
|--------------|-----------|-------------------|----------------|
| Hospitalised | 31 | 5000.00 | 155 000 |
| Doctor | 215 | 172.6 | 37 109 |
| Medication | 357 | 58.45 | 20 867 |
| Total | | | 212 976 |

The total number of medications reported was 536. Thirty-one respondents were admitted to hospital with water quality related ailments. To establish a minimum cost of medical treatment resulting from the 2006 Dusi Marathon, the medical events reported by the respondents were multiplied by an approximate costing. Prices were obtained by consultation with regularly used medical practitioners, hospitals and pharmacies in the Pietermaritzburg area. The cost of hospitalisation is an approximation based on admission for one night. Doctors' visitation fees are for a single consultation with no medication, tests or procedures, and medicine prices are based on a single prescription of a commonly used anti-biotic. There were many different types of medications taken, and the costs vary considerably. Anti-biotics fall in the low to middle price range and it was felt this would balance both the cheaper medications and more expensive, and still establish a minimum cost. The breakdown of medications taken during and immediately after the event are illustrated in Figure 5.10. The price of tests varies considerably and the patient is often required to have multiple tests before a diagnosis can be determined. In addition, tests were not specified in the questionnaire and therefore could not be included in the cost analysis. The minimum costs incurred by all respondents totalled R212 976.00. It is likely that this amount could double or even treble if additional costs of multiple doctor visitations, tests and additional hospital fees are included.

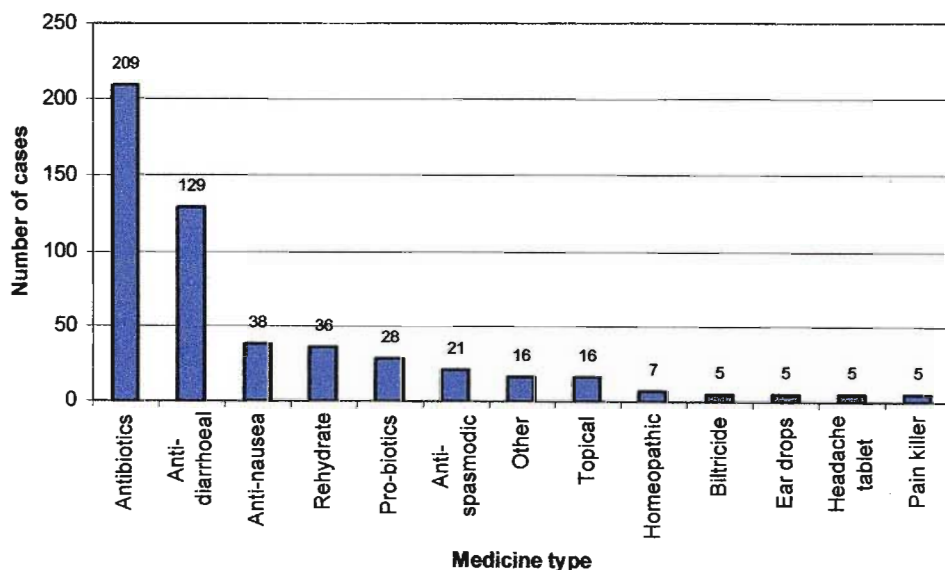


Figure 5.10 Medications taken by respondents during and immediately after the 2006 Dusi Canoe Marathon

5.2.4 Regional differences in susceptibility to illness

The Dusi Canoe Marathon is raced by canoeists from all over the country. The majority of the field is, however, based in KwaZulu-Natal, as this is the home of the event. The questionnaire included information on regional training venues, and this could be used to determine regional differences in susceptibility to illness (Figure 5.11). The results indicate that respondents from Gauteng had the highest percentage of illnesses (51.28%), with Western Province second (43.33%). KwaZulu-Natal and Central Districts (including the Free State) were next, with 37.24% and 38.46% respectively; and the region with the smallest portion of respondents reporting ill was the Eastern Province.

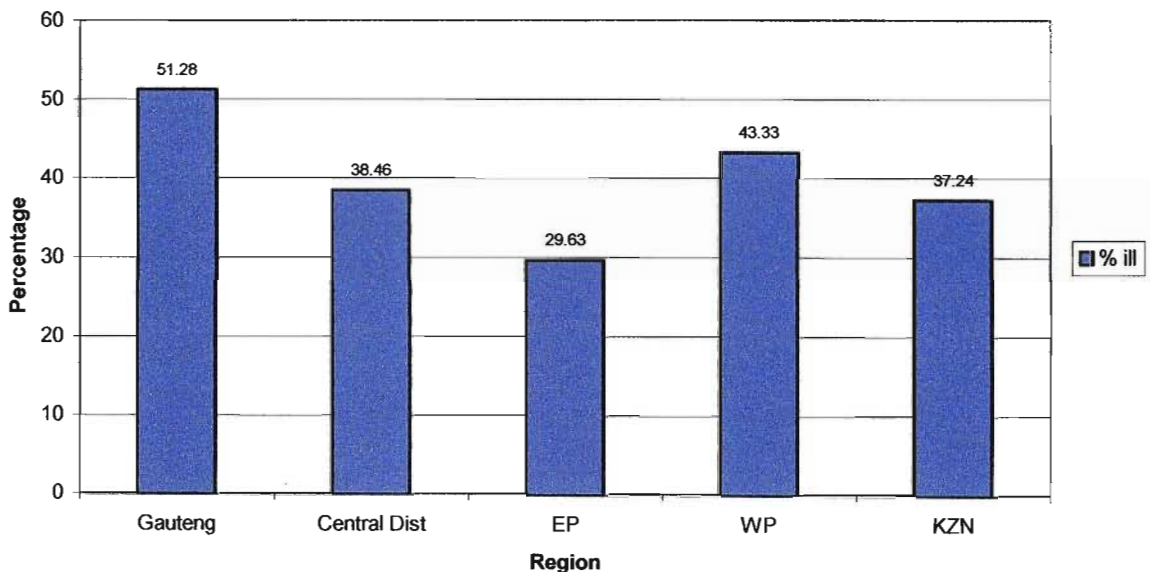


Figure 5.11 Percentage ill by region

There could be any number of contributing factors as to the above results. KwaZulu-Natal having a slightly lower infection rate may be attributed to paddlers building up an immunity to the pathogens in the water. In number terms, the KZN canoeing community make up the majority of paddlers taking part in the event, and there is a possibility that many who were ill did not report it as they have been ill similarly in the past and are accustomed to the process. On the other hand, paddlers from other provinces may not have experienced the infections from this area and are more likely to react more seriously to them.

5.2.5 Illness on previous Dusi Canoe Marathons

The statistics for those paddlers who have been ill on previous races was reviewed in an attempt to ascertain whether or not there is a trend in illness associated with racing in the Dusi Canoe Marathon or if this 2006 event was a once-off.

In the questionnaire survey, the participants were asked the question: 'Have you been ill as a result of doing the Dusi in previous years? If yes, please give a brief account of your ailment.' The results are shown in Table 5.7. The 'No. of paddlers' column indicates the split of those paddlers who were ill in the past and those that were not, while the 'ill in 2006' column indicates how many of those ill or not ill in the past were ill in 2006.

The results do not include those paddlers who attempted or completed their first Dusi Canoe Marathon this year (n=156)

Table 5.7 Previous Dusi ills and 2006 Dusi ills

| | No of paddlers (N=941) | | Ill in 2006 | |
|---|---------------------------|-----|-------------|-----|
| | Previously Ill | 362 | 39% | 228 |
| Not Previously Ill (Less those 1 st Dusi) | 423 | 45% | 359 | 85% |

By combining the figures for those who have been previously ill, and those who were not previously ill, but suffered some ailment in 2006, one can determine that 721 participants or 76.62% of the sample have at some stage been ill as a result of taking part in the Dusi Canoe Marathon.

The respondents were also asked to indicate the type of illness they experienced in the past, and the breakdown of these is shown in Figure 5.12. Similar to the 2006 event, diarrhoea is the most prevalent illness recorded in previous events with 286 cases (54%), while those in the 'other' category is the second most commonly reported with 131 (25%). Nausea and vomiting make up 15% (80 cases) and infected wounds 6% (29).

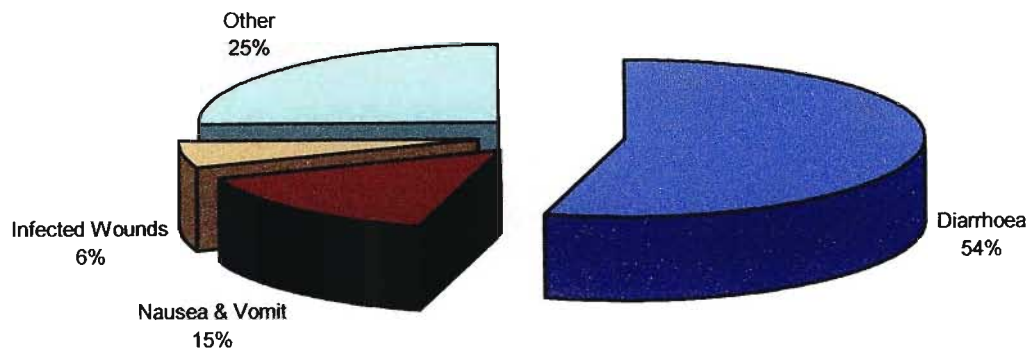


Figure 5.12 Division of illness from previous Dusi Marathons

Illnesses in the 'other' category covered a broader range than in this year's event and are listed in Table 5.8 alongside those reported in this year's event. The main illness categories are included in this table. A third column lists those reported in the Pietermaritzburg questionnaire. It must be noted that this data is not a subset of the Dusi survey, but a separate set from which any of the Dusi respondents have been removed. Many of the ailments reported were not given a diagnosis, either because the respondent did not seek medical advice or because the doctor was unsure of the illness and put it down to contact with dirty water. Some of the symptoms are listed here, in cases where no diagnosis was given. Symptoms included in the table range in severity from general weakness to unexplained dizziness to heart problems and infections that won't heal.

Lack of definitive diagnoses poses a problem for research, as exact numbers of illnesses cannot be gauged. Many of the symptoms or vague interpretations listed here are indicative of similar infections and could be caused by the same pathogen. For example 'bacterial lung infection', chest infection / respiratory', 'flu-like symptoms', Pneumonia' and 'throat infection' are all indicative of a pathogen affecting the respiratory tract and could indicate a common infection with a single pathogen. Similarly, diarrhoea – which is the most commonly reported symptom – can be caused by a wide variety of pathogens, some of which result in minor, self-limiting conditions and are simple to treat, while

others can be severe and result in hospitalisation and have considerable economic and social implications for the patient.

In addition to the obvious symptoms and illnesses, many of these infections have secondary complications. Two cases of Appendicitis were reported, both diagnosed by the doctors concerned as occurring as a repercussion of a bacterial infection contracted through contact with the water. A total of three Typhoid cases have been reported during this research, and a number of additional uncommon diseases such as Encephalitis and Leptospirosis, both of which are life-threatening. As with the latter case (case no. 21, Appendix D), the diseases are sometimes so uncommon that doctors are unable to provide effective treatment until the infection it is well advanced. A selection of the more severe infections as reported from this, and previous year's races, are included in Appendix D. Defining and mitigating these illnesses will need more detailed diagnoses of all infections, and a greater awareness among paddlers and local communities as to diseases and their symptoms.

Table 5.8 Summary of diseases as experienced by canoeists on the Msunduzi / Mngeni Rivers

| Illness | Previous Dusi's | Dusi 2006 | PMB survey | Total |
|-----------------------------------|-----------------|-----------|------------|-------|
| Amoebic Dysentery | 6 | | 2 | 8 |
| Appendicitis | 2 | | | 2 |
| Bacterial lung infection | 1 | 1 | 1 | 3 |
| Bilharzia | 51 | 20 | 30 | 101 |
| Blood parasite | 1 | | | 1 |
| Boils | 1 | 4 | | 5 |
| Cellulitis | | | 3 | 3 |
| Chest infection / respiratory | 2 | 22 | | 24 |
| Dizziness | 2 | | 1 | 3 |
| Ear infection | 1 | 20 | 2 | 23 |
| Encephalitis | | 2 | 2 | 4 |
| Enlarged Spleen | 1 | | | 1 |
| Eye infection | 1 | 5 | | 6 |
| Fever | 8 | 14 | 4 | 26 |
| Flu-like symptoms | 2 | | 1 | 3 |
| Giardia | 1 | | 2 | 3 |
| Headache | 1 | 8 | 2 | 11 |
| Heart Problems | 1 | | | 1 |
| Helico Bacter | 2 | | | 2 |
| Hepatitis | 6 | 2 | 6 | 14 |
| Illness won't go away | 9 | | 3 | 12 |
| Kidney / bladder infection | | | 2 | 2 |
| Leptospirosis | 1 | | | 1 |
| Liver infection | 1 | | 1 | 2 |
| Muscle cramps | 1 | | | 1 |
| Natal fever sores | 1 | | | 1 |
| Pneumonia | 1 | | | 1 |
| Serious infection that won't heal | 22 | 12 | 3 | 37 |
| Severe dehydration / Drip | 10 | 3 | 3 | 16 |
| Severe weight loss | 8 | | | 8 |
| Shigella | 1 | | 3 | 4 |
| Sinusitis | 1 | | | 1 |
| Stomach cramps | | 23 | | 23 |
| Stomach infection | 15 | | 4 | 19 |
| Swollen glands | 1 | | | 1 |
| Throat infection (Staphylococcus) | | | 1 | 1 |
| Tick bite fever | 16 | 8 | | 24 |
| Typhoid | 1 | 1 | 1 | 3 |
| Viral infection | 1 | | 5 | 6 |
| Weakness | 8 | 9 | 5 | 22 |
| Diarrhoea | 286 | 504 | 22 | 812 |
| Nausea & vomiting | 80 | 263 | 11 | 354 |
| Infected wounds | 29 | 115 | 5 | 149 |

5.3 Water quality in Msundusi/uMngeni Rivers

Water quality is the most influential factor in the spread of disease among canoeists taking part in the Dusi Canoe Marathon, and it, in turn, is influenced by a number of factors including rainfall prior to the event, and the condition of sewers and activities of industry in the catchments. Umgeni Water, as the principal water monitoring body in the Msunduzi catchment, test the *E.coli* levels at a selection of test stations (Figure 5.13) along the Msunduzi and its tributaries in Pietermaritzburg on a regular basis throughout the year. To supplement the organisation of the Dusi Marathon, additional test are carried out over the three days of the event.

During the 2006 marathon, samples were taken on day one of the event covering the stretch of river raced over the first day. On day two of the event, sampling was done covering the remainder of the river, including sites that would only be raced the following day. As a result, the *E.coli* readings for sampling stations on day three are not a reflection of the conditions in which the competitors paddled. This would normally be significant, given that there is a time lapse that contaminated water takes to reach stretches further down the river. However, the second day ends on Inanda dam, at which point any significant pollutants would be substantially diluted and would be unlikely to have an impact on the quality of water released from the dam for day three of the event. The readings for the 2006 Dusi marathon are illustrated in Figure 5.14.

The routine readings taken during the week prior to the start of the marathon (Figure 5.15) show an acceptable *E.coli* level for most stations in the Pietermaritzburg area, with a range between 80 and 44 000/100ml, with the highest recording being below the Baynespruit tributary. The readings taken four days after the event on the 25th January indicate figures ranging between 110 and 15 000 *E.coli* /100ml. The *E.coli* rating for safe - low risk of infection - full-contact recreational use (swimming) of water in South Africa is considered to be less than two hundred *E.coli* /100ml. There are no definitive guidelines for safe intermediate-contact (including canoeing) recreational use of water in this country (DWAF, 1996b). However, contact with water with an *E.coli* level exceeding 400 *E.coli* /100ml results in an increasing risk of infection with gastroenteritis. A reading of over 10 000 is considered a serious health risk (Terry, 2006), and the likelihood of contact with other, sometimes more serious pathogens, a considerable likelihood. Thus,

the results of water quality testing prior to the event indicate that many areas of the river were already over the 'safe' level.

An investigation into the readings taken on the days of the actual event (Figure 5.14) reveal a considerably dire situation that was not evident from looking at the routine testing done by Umgeni Water. The *E.coli* reading at the start of the marathon at Camp Drift was 54 800, and escalated to 141 400 *E.coli* /100ml below the confluence with the Baynespruit tributary. The significant change in water quality was attributed to the severe rainfall event on the late evening of the 18th January 2006, the night before the start of the race. The heavy rain resulted in a flash flood in the Pietermaritzburg area, and a number of sewer pipes reportedly burst near tributaries to the Msunduzi. The rain event occurred too late in the evening for any substantial warnings to be given to paddlers arriving for their 5:30am start the next morning.

Two factors can immediately be deduced from these results. Firstly, the routine *E.coli* sampling cannot be used as a reliable forecast for water quality conditions as the readings can fluctuate by substantially different levels within a very short period of time following a high rainfall event or sewer leak. Secondly, the water quality is reliant on a range of external factors that could change at any given moment, such as a sudden discharge of waste from an illegal dump site, or failure of the sewer system following a blockage, allowing raw sewerage to flow into the river.

Clearly, taking part in the Dusi Canoe Marathon is a high health risk as participants are exposed to critical levels of *E.coli*, and numerous additional diseases. Furthermore, participants are not suitably well informed of the water quality situation as conditions fluctuate too quickly for adequate warning. The state of affairs is unacceptable by international standards and brings a multitude of negative economic and social factors to an event that should provide positive economic and social input to the cities and the province. The situation also points toward a far more widespread problem of water-related illness among communities that use the river daily for domestic requirements and do not have access to sophisticated medical facilities, or the funds and knowledge to utilise them.

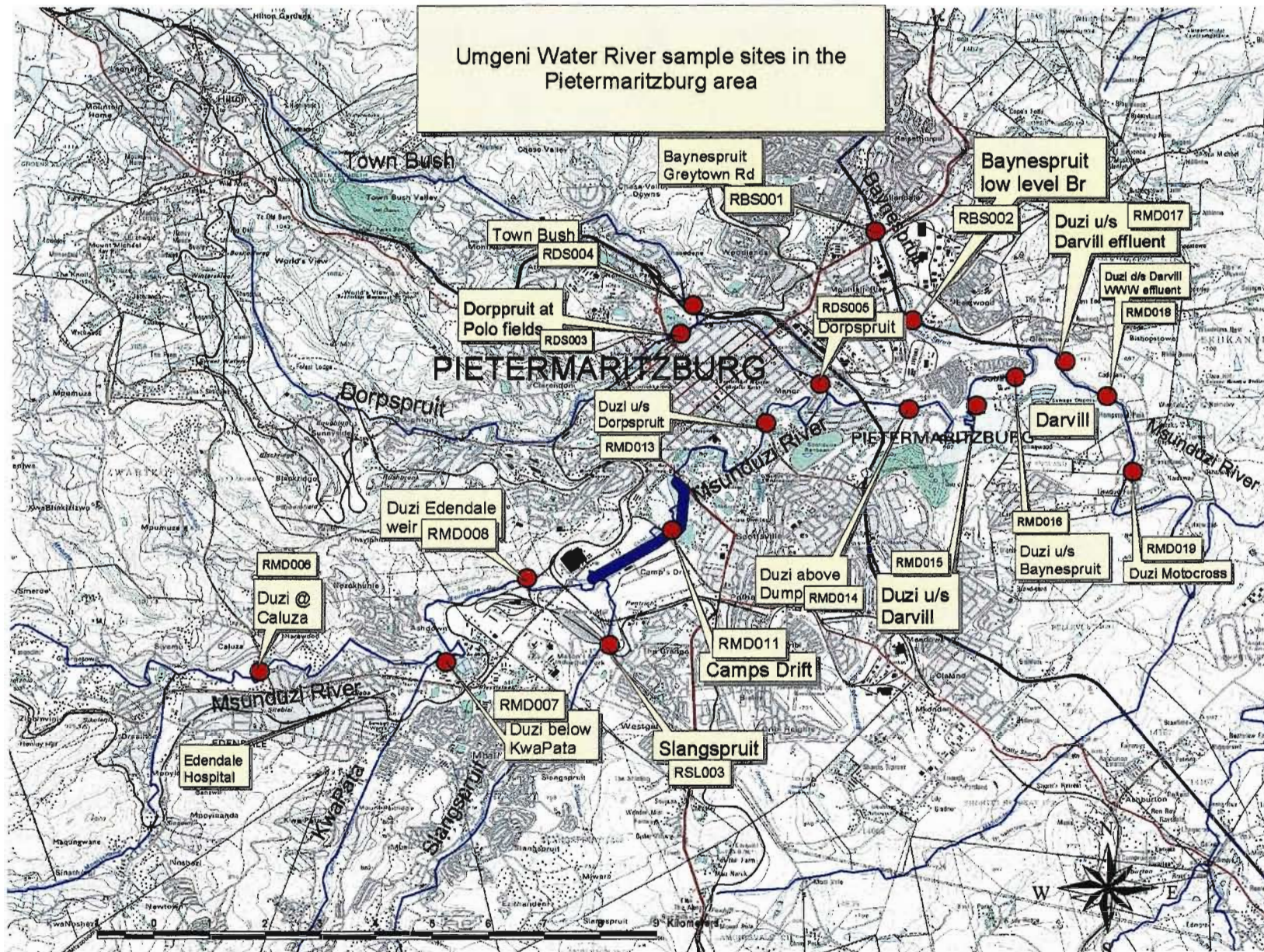


Figure 5.13 Umgeni Water test station sites in the Pietermaritzburg area (courtesy of Umgeni Water)

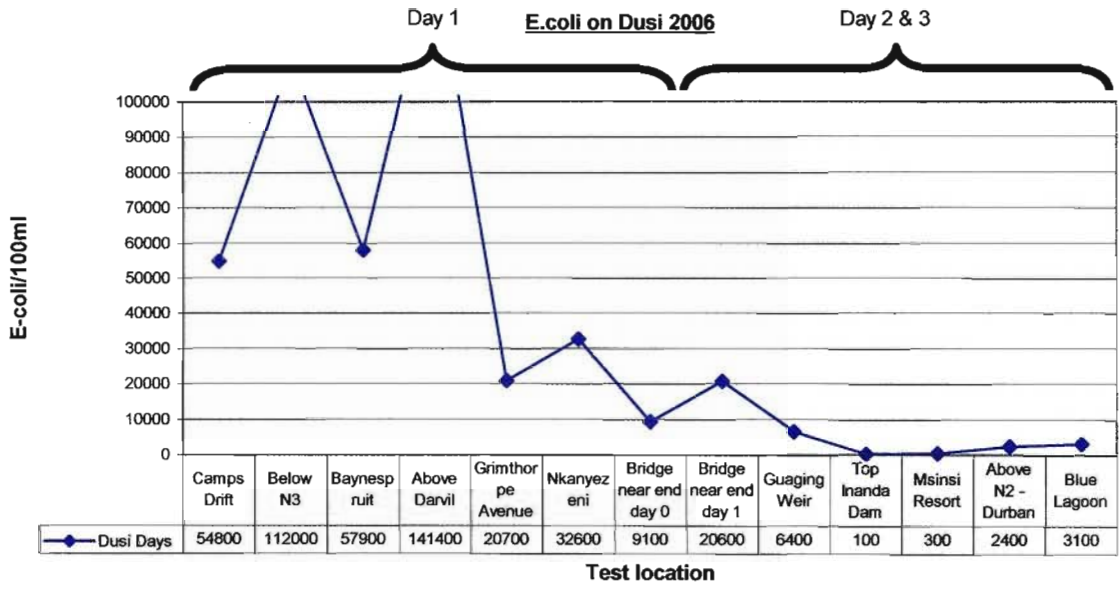


Figure 5.14 E.coli readings for the 2006 Dusi Canoe Marathon

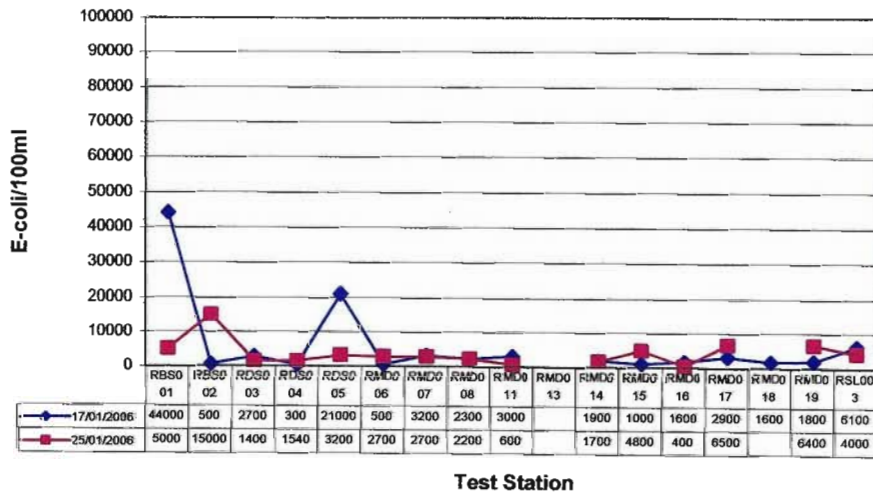


Figure 5.15 Routine E.coli tests during the week prior to and after the 2006 Dusi Canoe Marathon

CHAPTER 6

CONCLUSIONS

The focus of this dissertation was to explore the extent of the issues surrounding river health and water-related disease in the Msunduzi and Mngeni River Catchments using canoeists as a representative community of river users. Canoeists, while not using the rivers for domestic and every-day livelihood resources, train and compete on the Msunduzi and Mngeni Rivers up to five or six days a week. In addition, they are a community that is generally well-educated, within a financial bracket with access to detailed medical and scientific resources and willing and interested in contributing to the research. For this reason, they are an accessible sample population from whom accurate and detailed information can be gained. It was assumed, furthermore, that the risk of contracting illness by canoeists would reflect directly on the risk to communities who utilise the river daily for domestic uses, and thus this research forms a foundation from which to ascertain the need to undertake further investigation and resource management strategies in the catchment

Research into relevant, available literature and past projects of a similar nature has highlighted that combating water-related illness is a global problem that is constrained by numerous factors, both natural and anthropogenically induced, that exacerbate the spread and initiate the emergence of new and re-emergence of old diseases. Healthy river systems that could ordinarily recover from disturbance and regulate the existence of pathogens, have been degraded – primarily by human interference – to such an extent, that they can no longer carry out this function, and as a result the valuable goods and services they provide are lost.

In South Africa, and in the research area in particular, the above is true. Past research into the state of the rivers in the Mngeni and Msunduzi Rivers attest to severe alteration of the resource, with resulting environmental, social and economic consequences. Many solutions and recommendations have been proposed in the form of both research and legislation, but to date much of the legislation has not been effectively implemented, and many of the scientifically researched solutions are overlooked *in lieu* of higher order social

and economic priorities such as the Aids pandemic and education objectives. While this is the case, however, there are many private and public organisations and governmental departments motivated towards achieving the goals set out in the National Water Act (Republic of South Africa, 1998) for the benefit of both the social and environmental needs of the catchment.

The results of both the Schistosomiasis testing and the Dusi Canoe Marathon survey conducted during this research confirm that use of the Msunduzi and Mngeni Rivers for recreational and professional canoeing places competitors at risk of infection with water-related illness. In certain cases the symptoms of such infection have been life-threatening. Appendix D provides examples of the more severe and life-threatening cases that were reported.

The *Schistosoma haematobium* infection survey conducted in this study indicates that there has been an increase in the rate of Schistosomiasis among canoeists over the past twenty years. Infection rates in the Nagle Dam area of the catchment are particularly high, indicating that those communities in close contact with the river for more regular activities than canoeing are at a higher risk of infection.

As discussed briefly in 3.1.1, ongoing land-use activities and the overall change in water conditions and temperature in the future may have a negative impact on the effort to reduce Schistosomiasis in the catchment. Contributing factors such as bad land-use, water extraction and climate change may support the increase in the population of hosts snails for the parasite. These factors are, however, less significant than the immediate issues of community development and education, and the enforcement of best integrated catchment management practices in all sectors. Focusing attention on more localised issues will improve the lives of the people, and the condition of the river, and ultimately contribute less negatively to the larger scale issues of climate change and global warming.

Ensuring the management of Schistosomiasis in this catchment will require a considerable amount of planning, education and a long-term treatment strategy. Control programmes and treatment of communities in the upper reaches of the catchment will help reduce the risk in other areas (Johnson and Appleton, 2005). It is recommended that further detailed

research be conducted into *Schistosoma haematobium* infection rates and treatment regimes at schools in the area, as well as research into the prevalence of *S. mansoni* and other water-related diseases present in those communities.

The post-2006 Dusi Marathon survey confirmed the high rate of water-related disease infection of canoeists taking part in the annual marathon. Diseases ranged from minor bouts of diarrhoea and vomiting to severe illnesses such as Hepatitis and Typhoid. In addition, the results substantiate that risk of water-related infection of canoeists was not limited to the 2006 Dusi Canoe Marathon, but has been a prominent factor in the sport in the catchment for many years. This indicates a chronic problem that needs to be addressed to ensure the ongoing success of the event, and the contribution that it makes to the catchment and its communities as a whole. The evidence goes beyond that of supporting the canoeing event, but into everyday life of communities living along the banks of the Msunduzi and Mngeni Rivers.

Water quality records verify the link between water-related illness and high pollution events, where the river is contaminated with sewerage or industrial waste following high rainfall episodes. The Msunduzi River is severely and regularly affected by these events, placing communities at high risk of infection. In addition, the timing and severity of these events is unpredictable, as they are heavily dependent on natural rain events and the unreported activities of industry within the catchment. As a result, warning systems and mitigation efforts are limited in their extent. This was highlighted in the 2006 Dusi Marathon, where a storm event took place the night before the race, changing the water quality status from reasonably good to very bad within a few hours, and leaving no effective time to warn paddlers as test results had not yet been confirmed by the start of the race. Canoeists suffered the consequences of the contamination, and the effects were still evident many days after the finish of the marathon.

The social and economic burden of water-related illness on canoeists is reflected in this research, and indicates that many work days are lost, and high costs of medical treatment are incurred as a result of avoidable water-related illness contracted while paddling on the Mngeni and Msunduzi Rivers. Canoeists, generally, are in a position to afford medication and treatment, whereas many of the communities living in the river valleys

are not, and rely on state provided medical facilities. As a result, progress in combating water-related disease in these communities is only as adequate as the services provided to them. Education and awareness will contribute to equipping them with the knowledge and resources to recognise and understand the diseases they are infected with, and to deal with them.

The collaborative efforts of health departments and concerned bodies, such as the Duzi Umngeni Conservation Trust and the Catchment Management Fora, must be supported in their activities to help combat illness in the rivers by both the public and the municipalities. Recognition of the problems, and responsibility needs to be taken in the management of the catchment, and in bringing to task those groups and organisations that are in contravention of the environmental regulations. The municipality of Pietermaritzburg – who by law are responsible for overseeing the management of the city's environment and the health of its citizens – needs to be publicly seen to be actively involved in activities and strategies to improve the situation. In short, the issues of water-related disease are not going to improve without dedicated effort from all parties concerned, from the supply of sanitation services and education from city municipalities, to utilising that sanitation and the knowledge gained from education programmes by communities. Like the systems that contribute to the functioning of a river, water resource management and water-related disease management are composed of systems of input factors that need to be healthy in themselves, and function in an integrated manner.

A major contributing factor in mitigating and reducing the level of disease associated with the catchment is the encouragement of better catchment management at all levels of land-use, from agriculture to infrastructural development. As mentioned previously in Chapter 2, innovative alternatives to current management strategies can significantly reduce the level of harm imparted by catchment activities. In agriculture this could include alternative grazing sites, or fencing to keep stock animals away from the river banks where they create paths for erosion and pollute the water with faeces and urine, thereby initiating the spread of disease. Infrastructural development could include locating new housing developments further from catchment areas and ensuring sewerage removal is effective. In some areas of the catchment, wetland rehabilitation is being implemented with great success. These efforts are often, however, initiated by private

organisations in areas where there is an existing structure of conservation. They need to be extended into areas of the catchment that are currently highly disturbed.

In many instances the most vital component of integrated catchment management is the provision of education, from basic sanitation to awareness of the value of the rehabilitation and conservation of natural resources and how each individual is responsible in assisting that process. This education includes the upliftment of women and girls, and inclusion of their input in decision-making and management strategies. It further includes the education of government officials and management personnel of powerful organisations and companies who need to be both open-minded to, and responsible for implementing non-traditional methods of operation that will still provide for them, but will also provide for the needs of the catchment.

In some cases, these people in power may be the very people who took part in the Dusi Canoe Marathon, and are subjected to the impacts of failing catchment management every time they go training. The efforts of organisations such as DUCT and the various catchment management fora could go a long way towards enlightening them of their responsibility in official areas in their lives that could ultimately improve the condition of their recreational activities.

Finally, as detailed above, the two rivers used in this study are examples of excessively over-utilised, highly urbanised rivers subject to many, if not all, of the water and land management problems experienced in both developed and developing countries. They are relied upon by humans for every conceivable use, from domestic washing and drinking water supply, to heavy industry and waste disposal, to recreation and aesthetic appeal for tourism activities. Unfortunately, the majority of people relying on the river resource in this manner are either unaware or disrespectful of the damage that is being done as a result of human activities, and the negative impact that damage will have on their overall well-being. It is hoped that the interest drawn as a result of this project, and the products – articles, presentations and discussion that emanate from this dissertation will help bring about more awareness of the disease-related implications of unhealthy river systems, and support those organisations that are working to improve them. Among the canoeists that utilize the river on a daily basis, this dissertation is hoped to

raise awareness of the risks of contracting illness from the water and options for mitigating and dealing with those risks so that participants are informed and can take positive action.

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APPENDIX A

Bilharzia testing of Dusi Canoe Marathon Competitors at the 2006 Dusi Canoe Marathon Information for volunteers and Declaration of consent

1. Aims of the project:

The World Health Organisation recognises the Disease Bilharzia (Schistosomiasis), caused by the trematode parasites called Schistosomes, as the second most socially and economically debilitating disease in tropical and subtropical areas; the first being Malaria. As a disease borne by water, and in a country where a large majority of the population rely on potentially infected water supplies in rivers and streams, there is very real concern relating to the presence and control of this parasite in South Africa. Evidence of the occurrence of Bilharzia in local canoeists who train and compete on the Msunduzi and Umgeni Rivers, indicate that the disease is definitely present in our rivers, if not on the increase. Canoeists are recreational users of the rivers, and are in contact with the water at most times of the year in all conditions. This project aims to reveal the extent to which canoeists are infected with the disease, with a view to providing a backdrop for further Bilharzia management strategies in the Msunduzi/Mngeni region.

2. Investigators details

- a. Kirsten Oliver – Masters student at the Centre for Environment and Development, University of KwaZulu Natal.
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Cell number: 0833698040
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3. Independent Person

- a. Dr Trevor Hill – Project Supervisor
Geography Department
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4. How subject was identified

This study is an attempt to ascertain the extent to which the Bilharzia disease is prevalent in canoeists who train and compete on the Msunduzi/Umnjeni rivers. As participants of the Dusi Canoe Marathon 2006, and as active canoeists around the country you are an idea candidate for the research.

5. Explanation to subject

a. Procedure

All possible volunteers are supplied with the necessary sample container, which they must fill and return to the information desk – which will be available at the registration day and at each overnight stop of the Dusi. You will also be supplied with a set of instructions and general information pamphlet.

b. Possible discomfort or hazards

There are no hazards associated with the test. You will not have to get the sample under supervision, and may do so at your leisure and in your own home if you wish

c. Involvement time

Involvement requires the time taken to obtain your sample and return it to the information desk.

6. Benefits to subjects

The Bilharzia test will be provided free to all volunteers/subjects, and your results will be forwarded to you.

7. Cost

There is no cost to subjects

8. Written, audio or video recordings

There is a written information form that needs to be completed to accompany this consent form and your sample.

9. When will data be disposed of

10. Confidentiality or anonymity

Personal information – names, addresses etc. will be collected for the purpose of administration and in order that we may send you your results once the analysis is complete. No personal information will be used in any documentation, publications or presentations emanating from this research.

11. Decision to not participate will not result in any form of disadvantage

If you choose not to participate, you will not be discriminated against in any way, nor will you be placing yourself at a disadvantage to those who choose to participate.

12. Voluntary participation

Participation in this research is entirely voluntary, and you may choose to withdraw from the process at any stage and for any reason.

DECLARATION OF CONSENT

I.....(full names of participant)
hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT

DATE

.....

NOTE:

Potential subjects should be given time to read, understand and question the information given before giving consent. This should include time out of the presence of the investigator and time to consult friends and/or family.

APPENDIX B

Information letter to 2006 Dusi Canoe Marathon Committee

Kirsten Oliver

Centre for Environment and Development

University of KwaZulu Natal, Pietermairzburg

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Cell: 0833698040

To the 2006 Dusi Canoe Marathon Committee,

RE: Bilharzia sampling for research purposes at the 2006 Dusi Canoe Marathon

I am currently doing my Masters degree in Environmental Management at the University of KwaZulu Natal in Pietermaritzburg. My final research paper is a study of the water-related diseases in the Msunduzi River. As part of this research, and with the support and assistance of Doctor Maurice Mars (CSA medical official), I would like to conduct a survey of Bilharzia amongst canoeists taking part in the 2006 Dusi Canoe Marathon. A similar survey was done about fifteen years ago on the Dusi, and I believe the results of repeating the exercise will be to the benefit of all concerned. Whilst the reality of waterborne diseases is not a pleasant one, and often concealed to avoid bad media, it is a reality nonetheless, and the more we know and understand about the various diseases, the more we will be able to assist in making sure the media hype is positive.

As a very basic outline, what we would require to conduct the survey is as follows:

1. The distribution of information pamphlets to all canoeists telling them about the disease and about the survey and inviting them to take part.
2. The inclusion of testing containers - urine sample bottles - in the packages going out to canoeists on registration.
3. A table at registration and at each overnight stop to display information and collect samples.

I have only now obtained clearance from the University to undertake the sampling (all such research needs to go through a process of ethical clearance by the university). I realise it is very close timing as the race is next week, but as the preliminary preparations have been finalised already, I do not foresee any problems.

Please let me know if this is in order and whom I should communicate with regarding the distribution of sampling bottles with the registration packets and a table for information on the day.

Should you require any further information, please do not hesitate to contact me.

Regards

Kirsten

APPENDIX C

Dusi Sickness Survey 2006

| | Questions | Answers |
|----|--|---------|
| 1 | Name of paddler? | |
| 2 | How many Dusi Marathon's have you completed? | |
| 3 | Did you take any medication/vitamins before the Dusi or during the race to try to avoid getting ill? If yes, please indicate what type. | |
| 4 | Where you a front or back paddler? | |
| 5 | How many times did you swim during the race? Please indicate below and give place/rapid names if you can. | |
| | Day 1 - before Campbells? | |
| | Day 1 - after Campbells? | |
| | Day 2 - before Ngumeni portage? | |
| | Day 2 - between Ngumeni and the dam? | |
| | Day 2 - on the dam | |
| | Day 3 - before Burma Take-out | |
| | Day 3 - Between Burma take-out and the Pump house weirs? | |
| | Day 3 - After the pump house weirs? | |
| 6 | Do you recall swallowing any water at any stage? (Even if just going through a wave) | |
| 7 | Did you get ill or experience any of the following during or after the 2006 Dusi Canoe Marathon? If no to all, please skip to number 14. | |
| | Diarrhoea (more than one loose stool in a 24 period)? | |
| | Nausea or vomiting? | |
| | Infected Wounds? | |
| | Other illness (e.g. ear infection, chest infection) please specify? | |
| 8 | Did you see a doctor? | |
| 9 | Were you hospitalised? | |
| 10 | What was the diagnosis? (Name of Infection or illness) | |
| 11 | Did you take any medication? Please specify name or type. | |
| 12 | When did you first start to feel/notice infection? | |
| 13 | How long did it last? | |
| 14 | Have you been ill as a result of doing the Dusi in previous years? If yes, please give a brief account of your ailment. | |
| 15 | Additional Information? | |

APPENDIX D

| Case No. | Sex | Year | Symptoms | Doctor | Hospital | Diagnosis | Additional Information |
|----------|-----|------|---|--------|----------|--|--|
| 21 | M | 1998 | Sunday after Dusi, extreme headache, eyes on fire, hot & cold, symptoms for typhoid, malaria, hepatitis B | Yes | Yes | Undiagnosed, doc treated for Typhoid. Finally Leptoserosis. It was determined that he was suffering from organ failure with both Liver and Kidney, but could not determine the reason as to why the organs were failing. | Paddler lost 19Kg in the space of 5 days and all muscle disintegration the physical strength disappeared in that time. He was unable to perform a full days work for up to a year thereafter. He would get very tired and confused. Would get lost travelling to places he had known for some time. He seems to have fully recovered, but the doctors told him that his recovery time after exertion will be slower, and he should not do marathons in quick succession i.e. fifty miler / Canvas paddle to Durban / Dusi Marathon. Lyle did find this to set him back and he still has regular checks on organ function in case of re-occurrence. |
| 27 | M | 2004 | Constantly feeling sick and tired | Yes | Yes | Bilharzia & unnamed kidney, bladder virus, also prostate, testicular & colon cancer, level 5, Encephalitis | Further to my email sometime back, I have just been diagnosed with the above; I feel as a result of tripping the first day 50-miler route recently for the club. Am on treatment and have been off work for 8 days. Training, squash and paddling is not an option |
| 28 | F | 2004 | Headaches, nausea, total lack of energy | Yes | | Bilharzia & unnamed kidney, bladder virus | |
| 132 | M | 1985 | Tired, Yellow, lack of tolerance to beer | Yes | No | Hepatitis A | |
| 34 | M | 2004 | Headache, nausea, sore body | Yes | No | Hepatitis B | Still only light beers |

| | | | | | | | |
|----|---|------------|--|------------------------------------|-----|--|---|
| 5 | M | 2005 | Fatigue, stomach pains, diarrhoea | Yes | No | Guardia, Bilharzia | |
| 35 | M | 2001 | 1. Diarrhoea for several weeks | Yes | Yes | Giardia | 1. 2004 Tried training again Hospitalised again 2 days with Gastroenteritis. |
| 36 | M | 2004 | Tiredness, stiff legs, permanent numb bum, unable to empty bladder | Physio, nuero-surgeon, neurologist | Yes | Spinal bilharzia, egg laid in spinal cord | Initially diagnosed as a spinal tumour but on seeking a second opinion and many more tests, it was confirmed it was a strain of bilharzia. |
| 41 | F | 2003 | 1. Fever, pain and swelling from a minor scratch on the lower right leg. | Yes | Yes | Severe Cellulitis | In 1996 after the Dusi, both my partner and myself had septic sores on back and legs which persisted for a couple of weeks. Otherwise we have both had the odd bout of Dusi guts (usually diarrhoea, but once vomiting after swallowing a mouthful of water on the fish ladder) from time to time |
| 42 | M | every year | Dusi guts, Hepatitis, Bilharzia, infected wounds. | Yes | No | Shigella, Hepatitis, Bilharzia, Infected wounds | |
| 47 | M | | 1. Fatigue and loss of weight, later on tingles in the left side of body | Yes | Yes | Localised lesions arising in the insular cortex on the right and asymmetrically prominent right temporal horn. Diagnosis may be one of the following - an AVM, either with the surrounding oedema or possibly a small bleed or a localised vasculitis In hospital for total of 10 days. | 1. Antibodies for bilharzia IgM (flag reference = < 3.2 EIA unit) High at 5.00. Interpretation Positive; Antibodies for bilharzia IgA Negative; Antibodies for bilharzia IgG (flag reference = < 0.9 EIA unit) High at 3.20 Interpretation High Positive; Eosinophilia (flag reference = 0.02 - 0.5 x 10 ⁹ /L EIA unit) High at 0.85; 2. Taking epileptic drugs to control seizures to be reduced over 2 years. Unable to train for at least a year to ensure no re-infection. Unable to dive due to pressure effects on drugs. Recovery still unknown. |

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| 50 | F | 2002 | Dysentery: Fever, Diarrhoea - passing blood clots; Bilharzia: Nausea, tiredness, rash on legs, diarrhoea, weight loss; Dusi Guts: Diarrhoea | Yes | No | Dysentery (which since has resulted in a leaky gut, which since has been corrected); Bilharzia (high levels) | |
| 52 | M | 2000 | 1. Severe dysentery, fever | Yes | Yes | 1. Amoebic dysentery; Shigella (2005) | Take Biltricide annually |
| 71 | M | 2005 | Infected toe from pedal friction burn | I am a pharmacist | No | Cellulitis | |
| 72 | M | 2003 | Infected blister on hand, v. swollen arm. Septicaemia | Yes | Yes | cellulitis | Could have led to disfigurement |
| | F | 2005 | Severe headaches, dizziness | Yes | Yes | Encephalitis | |
| 73 | M | 1980's | Hallucinations, high fever | Yes | Yes | Typhoid | Two fellow paddlers from the same club had same at same time - all in hospital together |
| 484 | M | 2004 | | Yes | Yes | Pneumonia | Some bug got in my lung |
| 548 | M | 2004 | | Yes | Yes | Bacterial lung infection lasting 2 months | |
| 535 | M | 1991 | Terrible stomach cramps for weeks | Yes | No | | 1. I was sick for about 3 months in 1991 when the Pmb City allowed raw effluent to be discharged into the river. I work in the field so I knew it was untreated sewage. I took them up on this and they first denied that one of their dams had overflowed. A few years later one of the engineers admitted (unofficially) that it had in fact happened. I had terrible stomach cramps for weeks and had to take several antibiotic courses. The river was very full that year. |

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| 777 | M | 2004 and 2005 | Nausea, throwing up | Yes | Yes | | 2005, nausea, throwing up, after day two. 2004, got very sick about 3 weeks after Dusi. Lasted about three months, lost about 10kg, went for many, many tests, could not find anything. Doctors eventually thought it was a parasite in my blood. |
| 174 | M | 1993 | | Yes | Yes | Bilharzia | Bilharzia 2 times. After my 2nd Dusi 1993 I had problems and the local doctors treated me for prostate. It did not get better and I went to see an urologist in Bloemfontein. He said that the symptoms were that of bilharzia and he done a scope, which resulted positive. It cleared after treatment. After last years Dusi I had the same symptoms and straight away took the bilharzia treatment. |
| 123 | F | | Infected wounds | Yes | Yes | Celulitis | Dusi guts on a few occasions and on one occasion severe cellulitis with systemic symptoms in lower leg after minor scratches requiring medical treatment and putting me in bed for 3-4 days |
| 315 | M | 1993-1994 | Many | Yes | Yes | See additional information | Got Dusi guts on 50-miler 1993. Completed Vaal 1993 and Dusi 1994 still having Dusi guts. I was extremely ill after 1994. Duzi. I got a few secondary infections / illnesses as well. Tick bite fever, Chicken pocks (for the 2nd time, had them as a child), severe Bilharzia, Nausea and vomiting, had Dusi guts for a total of 7 months. Under went a colonscopy in mid 1994, they couldn't culture the tissue samples. Sterilized my intestines / stomach and then re-introduced all the various lacto flora. I lost 11kg during the whole ordeal. Only dared to paddle the rivers again 1998. |
| 431 | M | | | Yes | Yes | Stomach infection | HAD TO HAVE STOMACH PUMPED DUE TO INFECTION |
| 256 | M | 2005 | | Yes | Yes | Bilharzia | I have had Dusi guts after a 50 miler event. I have also had Bilharzia which was probably contracted from the Dusi. I recently had my appendix out and Bilharzia was diagnosed as the cause of the appendicitis. |

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| 802 | M | | | Yes | Yes | Hepatitis D | Normal Dusi guts type symptoms & in the mid Eighties I contracted Hepatitis D Of which I'm led to believe is a very rare type of Hepatitis. Apparently there were only a few of us (Approx 5 paddlers) that had contracted This from the Dusi. At the time we gave blood samples after every Dusi for about 4 years, which were sent to Pretoria & to The USA to produce antibodies for this Strain of Hepatitis. Hope this info helps |
| 246 | M | 1996 | Infected wounds | Yes | Yes | | Severe infection in the knee, which necessitated 3 ops the remove necrotic tissue and subsequent plastic surgery in the form of a flat to cover the wound in 1996. Diarrhoea after 1991 Duzi. |
| 4 | M | 2005 | | Yes | No | None given | Was very seriously ill last year, went to the doctor - had a battery of tests, could not find out what it was, was told it was a mixture of viral and bacterial, lost 6kgs in a week and was sweating profusely, felt like malaria at stages. This was after I had treatment for bilharzias (about 2 weeks later) - very ill, basically could not work for 8 days. |
| 775 | M | 2004 | Many | Yes | Yes | None given | Yes in Jan/ Feb 2004 after tests as to why I was feeling grim after Dusi it was picked up I had a enlarged spleen, after various tests with a specialist physician, results inconclusive, but had diarrhoea, sweats, one day fine, next flat as a pancake, carried on for about a month, physician could never pinpoint what it was. |
| 37 | F | | 1. Tiredness, headaches, lower back pain, diarrhoea | Yes | No | Bilharzia | 1. The biltricide was supposed to get rid of the infection after one dose. I didn't paddle at all after the first dose or go into any "suspect" water or dams. The doctors did so many tests because they refused to believe that the infection was not going away. The symptoms at first were so mild that I didn't realise that I was sick - I thought I was maybe starting a depression, fighting off a cold, or had a low immune system. It's very difficult to tell if you have bilharzia without the tests because there are no foolproof symptoms and often the symptoms that the doctors look for are in extreme infections. |

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| 79 | M | Annual | Bilharzia, I have ranged from mid discomfort from the drugs to feeling really unhappy and having to take some time off work (usually a few hours in the day to rest). Diarrhoea = 3 days off work, about 2 being stuck in bed/on the couch, usually I'm ok after an afternoon off sleeping and drugging and running to the little white chair that with water. I'm usually off training for 3 to 5 days. | Yes | No | Bilharzia - positive every time. Various degrees of gastro. (I've even been kept in the doc's clinic for three hours on drips to rehydrate) (Ask Guy about what the river did to the cut in his leg! He was unable to run for about three months and went through several courses of anti-biotics. I don't think really minded though - he met Heidi at the doctor's rooms!!) Infection rates are highest after the first rains for the season and after BIG storms (and when Henley dam is emptied for the Ngwenya race). This is a result of all the muck on the banks being washed into the river. | I've just come back from Edendale Hospital ... I could show you a very interesting (you may find it interesting - it's a bit disgusting actually) sewer line. One manhole (or downstream pipe) clearly has some sort of blockage... The manhole is over-flowing. This is the interesting part. I was there at about 15h30 - not a peak time and there was a good flow coming from the manhole. That still was not the interesting part... This is the amazing (and possibly interesting) part... This has obviously been a regularly occurring problem as a trench has been made from the manhole to channel the overflow away and towards the nearby stream, which flows into the Duzi. Fresh cuts and grazes take significantly longer to heal after they have been in contact with water from the Duzi. I usually use Methyolate (sp?) to sterilise them after a thorough cleaning in the shower. This usually increases the healing rate from three weeks to one week. Also the cuts, usually, do not turn red (orange from the merthiolate only!) and there is little to no inflammation. |
| 81 | F | 2000 | Lethargy, fatigue. Serious infection | Yes | Yes | Bilharzia, Severe infection | During the 50 Miler last year, I had an accident where my left ear was partially torn away from my head (!!) and after being released from the hospital I had such a bad infection that I was readmitted for another few days. The doctor had not put me on antibiotics... even after a spill in the Dusi! |