Chapter One

Introduction

Industrialization in Lesotho has increased exports from the country and has generated considerable employment for the Basotho people. The government and the private sector have set up several wet industries (using more than 2000 cu m of water per day) that generate large amounts of wastewater discharges. Some of this wastewater is discharged either treated or untreated into the environment. This study aims to investigate the extent and impacts of water pollution by industries on water quality and health and livelihoods of communities living near the contaminated waterways.

Chakela Q.K (1999) and Mokuku et al (2002) and the National Environment Secretariat (2005) address the problem of effluents ensuing from the wet industries in Maseru being discharged into water ways. A study conducted by Pasco Waste & Environmental Consulting in 2005 found 'high levels of salts as well as colouring in the water' (*industrial wastewater in Maseru*). However, this study was based on once off sampling of wastewater only.

This research studied the water quality in the three industrialised areas of Lesotho, namely Thetsane in Maseru district, Ha Nyenye in Leribe district and Mafeteng in Mafeteng district. The effects of water pollution on communities living near the waterways were also studied. Areas for further research have been identified and recommendations made to prevent water pollution.

1.1 Research Problem

AGOA and other incentives have increased industrial investment in Lesotho. However, effluents from these industries are released (sometimes untreated) into waterways causing water pollution. Despite the ensuing pollution, not much has been done to study its impacts on water quality, health and livelihoods of communities living near the contaminated waterways. This study aims to address this research gap.

1.2 Objectives

The specific objectives of the research were as follows:

1. To study the water usage pattern of the community near the polluted waterways with an intention of finding the effect of water pollution by industries on the livelihoods and health of community.

2. To gather data about the state of water quality in industrialised areas of Lesotho and to compare them with South African standards, in order to know the extent of pollution.
3. To make recommendations based on findings for measures to prevent water pollution by industries.

1.3 Research Methodology

The Study Area

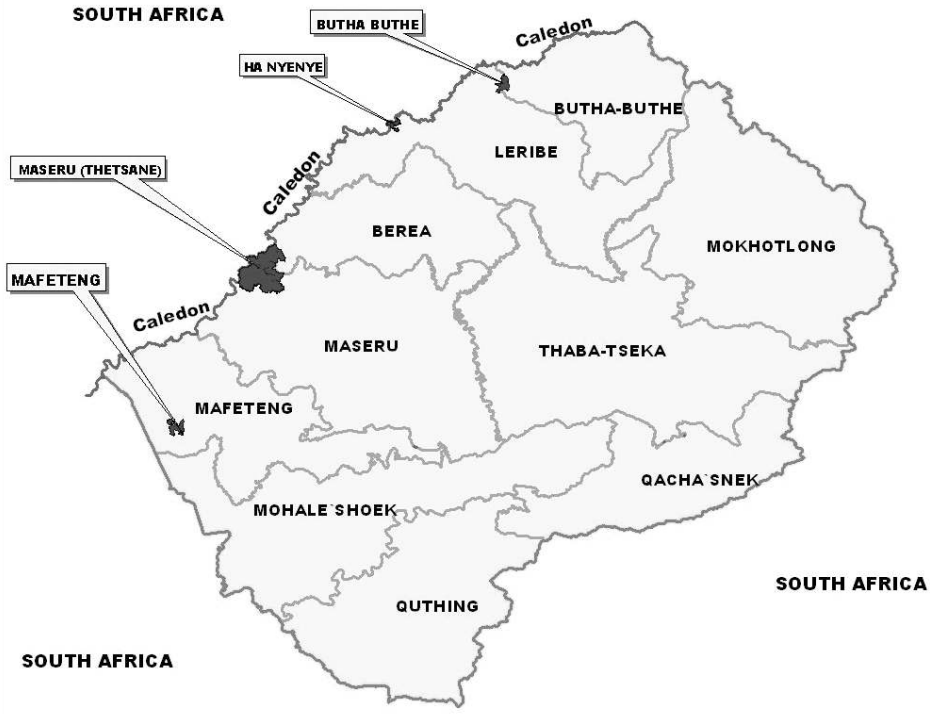

Figure 1: Map of Lesotho showing study areas Maseru, Mafeteng, Ha Nyenye and Butha Buthe

The study covered the industrialized areas of Lesotho, namely Ha Thetsane industrial estate in Maseru, Ha Nyenye industrial estate in Leribe District and Mafeteng in Mafeteng district. Butha Buthe which does not have wet industries was taken as a control point. A combination of desk studies, experimental techniques, focus group discussions and survey methodology were used in collecting both primary and secondary data relevant to this research.

Secondary Research

Secondary research was conducted by reviewing and studying several published and unpublished literature and documents, from Lesotho, the region and the world at large. Relevant maps were

purchased to identify survey sites. Previous research work in the area was also scrutinized and effort was taken to seek recent literature.

Socio economic survey

A reconnaissance survey was first carried out in the three study areas namely Ha Thetsane, Ha Nyenye and Mafeteng for the research team to have an overview of the types of waterways affected by industrial pollution. A total of 96 respondents were chosen from all the three areas which included the chiefs and community health workers. Purposive sampling was used to select the respondents. The questionnaire was designed by the Principal Researcher in consultation with the Research Assistants. The survey was conducted by research assistants after permission from community Chiefs. The survey was conducted during the day when the community was observed using the water. The analysis of data used simple frequency tables and charts and some of the questions elicited qualitative responses.

Laboratory testing of water samples

Water samples in the waterways both upstream and downstream of the industries were tested in the laboratory of Department of Water Affairs (DWA) to find out the extent of pollution. Water quality of two control points were taken for comparison, namely Hololo stream in Butha Buthe and Thaba Pechelo spring in Mafeteng. These water bodies were not affected by industries. Random water samples were collected for a period of four months from December 2005 and were passed on to the laboratory at Department of Water Affairs for testing. A minimum of five subsurface grab samples per waterway were collected from the sampling points. Samples were collected using one litre polyethylene bottles, mid-stream while avoiding air bubbles getting inside the bottles. All the sampling bottles were thoroughly washed with water, and rewashed with distilled water before sampling. Some parameters were tested on site using portable water testing equipments, while others were tested in the laboratory. The DWA laboratory used standard HACH® (1999) procedures of analysis for the parameters tested in their laboratory. For the control water bodies, data was already available from DWA database of ongoing monitoring. Further, all the water quality data was plotted against South African standards for comparison.

Discussions with stakeholders

Focus group discussions and interviews were held with officials from relevant institutions. Some valuable insights were gained from these discussions, which facilitated making recommendations. The participants for focus group discussions were from:

1. Commission of Water
2. Water And Sewerage Authority
3. National Environment Secretariat
4. Ground Water Consultants
5. Department of Water Affairs
6. Lerotholi Polytechnic
7. Maseru City Council

Chapter Two

Literature Review

2.1 AGOA and its impacts

One current asset for Lesotho is the African Growth and Opportunities Act (AGOA). Under AGOA, Lesotho and other African countries have been given zero-tariff access to the American market on a wide range of export items. This has had an impact on the textile and garment industry that plays a key role in making use of Lesotho's main resource – cheap labour. In 2000, exports of clothing to the United States were just over US$140 million. They rose sharply to just over US$215 million in 2001 when AGOA was launched in Lesotho. (The Courier, 2002, P 73)

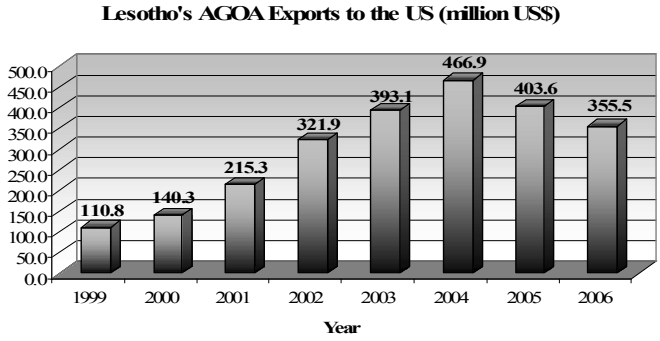

Figure 1: Lesotho's AGOA exports to the US [1]

Exports from Lesotho to the US have increased notably since 2001, when AGOA was introduced in the country. According to Bureau of Statistics (Manufacturing in Lesotho, Statistical report, 2005) number of people employed in manufacture of textiles and clothing (mostly AGOA industries) increased from 13,133 in year 2000 to 31,292 in 2004. Currently, the number of jobs in the textile and garment industry is 47,000.(SADC Today, 2006, P 7)

[1] Source: AGOA.info accessed on 2 Feb 2007
Note: AGOA was introduced in 2001 in Lesotho. Export data for 2006 was only available from January to November 2006

Although industrialization due to AGOA may be regarded a success story in terms of employment generation for Lesotho, water pollution that has ensued as a result could hardly be a victory.

The broad intention of AGOA is to create sustainable, long term development in Africa by "transforming the economic landscape… stimulating new trading opportunities for business.. bringing hundreds of millions of dollars of much needed investment into the region." Under AGOA, Lesotho has become the largest apparel exporter in Africa to the US. But the long term sustainability of the investment that AGOA has brought in is questionable. Lesotho's capital, Maseru where most of the investment has been introduced, now faces a double challenge to survival and growth:

1. Water is running out. There is barely enough water to supply the industries and people in Maseru as it stands. Without reform of water policy, growth will be limited.
2. Waste water from various factories is not being adequately treated, therefore producing levels of pollution that "is against all norms and will become illegal in Lesotho" (Andrew Gibbs and Tim Gibbs, 2003, P 3)

Gibbs concludes in his article that "Without sustained collective action in the area of water supply and pollution, it is likely that the AGOA initiative will just perpetuate a footloose pattern of investment by an international textile industry rather than provide an opportunity for sustained investment and growth that lies at the heart of the AGOA vision." (Gibbs et al, 2003, P 10)

2.2 Disposal of industrial wastewater

In his article, "A Water Supply and Pollution Crisis in Lesotho's Textile Factories: The Problems of Footloose Investment", Gibbs and Gibbs discuss the ineffectiveness of the disposal of waste water coming from the factories.

"From the factories, wastewater goes three ways. Some is fed into the sewage system to the government run Ratjomose Waste Water Treatment Works (RWWTW). This is designed to cope with normal sewage and brewery effluence (*effluents*), not effluence (*effluents*) produced by textile factories. Other effluence (*effluents*) goes into factory owned sitting tanks (also called oxidation tanks), before moving on. More still is put directly into a stream (Mosenyathe). All three processes fail to treat the effluence (*effluents*) effectively which then feeds into the Caledon River. The Caledon River then follows the Lesotho/South Africa border, before heading into South Africa, in the Orange Free State." (Gibbs et al, 2003, P 5)

"Due to the burgeoning population, peri-urban settlements have sprung up throughout Maseru. Much of this new influx have taken land near the textile industries that we are looking at. At the present moment, effluence (*effluents*) from the factories is passing through the settlements untreated. Due to the lack of space residents are forced to graze animals in land which is periodically flooded by these streams, when fibres from the factories build up in them. Residents are forced to unblock the streams of these fibres by hand to stop the flooding." (Gibbs et al, 2003, P 6)

"Effluent is discharged without treatment into the Caledon. This has led to the Caledon being one of the most turbid rivers in Southern Africa (readings are in excess of 14 000 NTU). And the current textiles investment is likely to increase by 20% the proportion of sediment and sludge in the river. This is against treaty conventions made with South Africa." (Gibbs et al, 2003, P 6)

A study funded by Department for International Development was commissioned to understand the Lesotho garment industry in 2002. The report found lack of treatment facilities for waste water to be one of the constraints for further development of the garment industry. "The principal environmental impacts associated with the Garment sector in Lesotho are that of over consumption of water and the discharging of untreated toxic effluents into watercourses against local legal requirements. The toxic effluent action poses a serious risk to the industries in this sector as it could result in boycotts of their products if this knowledge becomes widely known to their consumers." (Andrew Salm, William J. Grant, Thuso J. Green, John R. Haycock,Dr. John Raimondo, 2002, P 37).

2.3 Towards cleaner and greener industries

It has been argued that establishment of policies and legislations have been ineffective in controlling pollution. There is need to provide incentives for industries to develop a culture of environmental compliance. "The success of environmental regulations also depends on a culture of compliance that is a result of a country's legal traditions, the maturity of its institutions, the available resources, and the capacity and support of citizens and the private sector. Compliance does not automatically happen when requirements are legislated and issued; rather, it is achieved as a result of targeted efforts that encourage behavioural changes on the part of polluters." (Pollution Prevention and Abatement Handbook, 1998, P 120)

Some methods for encouraging environmental compliance have been elucidated in the Pollution Prevention and Abatement Handbook (1998, P 120-122) as; preparation of pollution inventories, dissemination of environmental information of enterprises, conduct studies on cleaner production techniques etc.

Mainstreaming environmental concerns is the way to sustainable development, as mentioned in the same publication; "the challenge is to find ways to integrate pollution prevention and abatement into the ways that cities are run, enterprises are managed, and people lead their daily lives." (P 10)

Communities can put pressure on enterprises and governments to encourage cleaner and greener production. Niamh Garvey and Peter Newell in their article "Corporate accountability to the poor? Assessing the effectiveness of community-based strategies"(Development in Practice, Volume 15, Numbers 3 & 4, June 2005, P 396) cites one such example. "Residents of Yellow Creek in the US state of Kentucky suspected that Middlesboro Tanning Company was polluting a local river, thereby affecting their health. The residents carried out their own health survey, which served to draw public

attention to the issue. The survey also provided the community with information it had not had before, providing a potential platform for future campaigning."

A study by Vinish Kathuria in the Journal of Ecological Economics, (Informal regulation of pollution in a developing country: Evidence from India, 2006) talks about how "the press can function as an informal regulator if there is sustained interest in news about pollution."(P1). "However, the effect of informal regulation on polluting behaviour is not immediate. Only sustained publicity about polluting activities of industrial units appears to lead to a significant fall in pollution generation." The author explains, "Our analysis suggests that lobbying efforts through the media by environmental activists and NGOs may be quite effective in influencing industry behaviour."(P 13)

Chapter Three

Research Results and Discussion

Secondary research revealed different sources of water pollution in Lesotho including from industrial wastewater. According to the State of Environment Report (2002), the possible sources of surface water pollution in Lesotho are:

1. Urban storm water drainage system,
2. Overflowing septic tanks and broken sewage reticulation system,
3. Industries such as canneries, pharmaceutical companies, brewing, ice cream factories, flour mills and clothing manufacturers,
4. Dipping and spraying free-range livestock using insecticides
5. High sediment yield from the watershed and
6. Slurry from mining activities

The possible sources of pollution for underground water in Lesotho are:

1. Leaching of substances – pesticides, herbicides, organo-phosphates into the water table.
2. Filtering through of latrine water,
3. Leaching from landfill sites.
4. Uncontrolled urban drainage systems and
5. Possible leachates from cemeteries.

(Second Sate of Environment Report, 2002)

This study focuses on water pollution in industrial areas only, most of the industries there came to Lesotho due to AGOA and other incentives. Lesotho became eligible for AGOA in 2001. The country needs to have met certain criteria for becoming eligible under AGOA. Countries need to "have established, or are making continual progress toward establishing the following: market-based economies; the rule of law and political pluralism; elimination of barriers to U.S. trade and investment; protection of intellectual property; efforts to combat corruption; policies to reduce poverty, increasing availability of health care and educational opportunities; protection of human rights and worker rights; and elimination of certain child labour practices". (www.AGOA.info, 2005)

However, environmental protection is not mentioned as a mandatory requirement under this act for industries.

3.1 Socio Economic Survey Data and Analysis

The Socio Economic Survey was conducted at Ha Thetsane, Ha Nyenye and Mafeteng during the months of August and September 2005. Most of the people surveyed were of lower income category and a sample size of ninety six in total was taken using purposive sampling. The questionnaire included questions pertaining to water usage pattern and effect of pollution on health and livelihoods of communities living near the contaminated waterways. Table 1 describes the Socio Economic Characteristics of the people surveyed.

Table 1: Socio-economic characteristics

Study Area	Age					Income				
	Min	Mean	Max	Sd	N	< M500 M2000	%	M500-	%	> M2000
Ha Thetsane	18	35.65	70	14.82	32	19	60	13	40	0
Mafeteng	18	32.93	6	15.00	32	26	81	6	19	0
Ha Nyenye	18	34.90	56	12.03	32	27	84	5	16	0

Min = minimum; Mean = average, Max = maximum, Sd = Standard deviation; N = sample size

When asked about the water usage pattern of the community, their responses were as given in Table 2. Although the communities surveyed do not use water from the sources for drinking or cooking, they indicated that if the water was cleaner they would like to use it for drinking and cooking. Presently, they have to purchase water from public taps for drinking and cooking purposes.

Table 2: Uses of water from the waterbodies

Location	Drinking/ Cooking		Bathing/ Swimming		Washing		Livestock		Building		Carwash		Irrigation		Fishing		Do not use	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Ha Thetsane	0	0%	2	6%	12	38%	4	13%	1	3%	0	0%	0	0%	0	0%	17	53%
Mafeteng	0	0%	0	0%	17	53%	6	19%	0	0%	1	3%	0	3%	0	0%	14	44%
Ha Nyenye	0	0%	1	3%	14	44%	2	6%	2	6%	2	6%	4	13%	4	13%	8	25%
Total	0		3		43		12		3		3		4		4		39	

The community was asked about what they found offensive about the waterways and their responses were tabulated under Table 3.

Table 3: Public Perception of water quality impacts

	Odour		Colour		Suspended solids		sewage	
Study area	No	%	No	%	No	%	No	%
Ha Thetsane	24	75%	23	72%	11	35%	9	28%
Mafeteng	16	50%	0	0%	31	100%	4	15%
Ha Nyenye	21	68%	8	26%	5	16%	17	55%
Total	61		31		47		30	

Community reported increased livestock mortality, increased skin irritations, increased staining of clothes and increased fish mortality after using the waterways subsequent to the arrival of industries. 25.3% households stopped using water from these sources due to pollution. They are now forced to buy water from public standpipes spending about M30 ($5) per month and taking between 10 to 30 minutes everyday to fetch the water. It must be emphasised here that those who cannot afford to buy water are forced to consume the waterways under study.

3.2 Water Quality Analysis

Water samples were collected at random during different times of the day from waterways at the three industrialised areas, Thetsane, Mafeteng and Ha Nyenye over a period of four months beginning December 2005. Data of water quality at Hololo stream, Butha Buthe and Thaba Pechelo spring, Mafeteng were obtained from Department of Water Affairs. The department has been monitoring these water sources as part of their ongoing monitoring of freshwater quality across the country. Table 4 below indicates the location of the sampling points with regard to their proximity from industries.

Table 4: Location of sampling points

No.	Name and type of water body	Location	Location from industry	Affected by pollution
1	Kelekeqe Stream	Ha Thetsane	Upstream	No
2	Kelekeqe stream	Ha thetsane	Downstream	Yes
3	Mohokare, river	Ha thetsane	Upstream	No
4	Mohokare river	Ha Ratjommose	Downstream leading to South Africa	Yes
5	Khohlo ea Masiu spring	Mafeteng	Downstream	Yes
6	Thaba Pechela spring	Mafeteng	No industries nearby	No (Control)
7	Moselinyane, Dam	Ha Nyenye	Opposite factories	Yes
8	Hololo stream	Butha Buthe	No industries nearby	No (Control)

The water quality of upstream water samples were compared with downstream samples. Statistical analysis (t - test for significance) was done to find out the parameters which had increased significantly from upstream values. The results of this statistical test are given in Table 5.

Table 5: Upstream and Downstream impacts

Parameters	Upstream			Downstream			Impact of Industries	Test of mean difference
	Mean	**Median**	**Stdev**	**Mean**	**Median**	**Stdev**	**(% change in quality)**	**T-stat**
Conductivity	409.72	372.5	93.27	855.84	740.5	245.72	117.07	2.94**
Chromium (VI)	0.02	0.015	0.005	0.125	0.01	0.015	668.02	12.61***
Copper	0.485	0.315	0.445	0.32	0.125	0.31	77.58	0.69
Nitrates	3.845	3.875	3.545	3.66	3.45	3.445	-4.71	0.09
pH	6.36	6.825	1.625	7.245	7.01	0.805	24.89	1.09
TDS	196.77	180	40.82	526.67	539.5	54.395	172.74	8.40***
Aluminium	1.175	1.175	1.625	0.945	0.945	1.335	-59.35	0.15
Calcium	107	110.5	37.875	156.17	160.5	14.495	60.65	2.1**
Chloride	0.455	0.305	0.53	0.09	0.09	0.085	-13.11	1.35
Iron	21.565	19.015	25.225	41.29	48.495	31.53	4.09	0.97
Manganese	0.59	0.175	0.955	0.39	0.295	0.465	286.99	0.37
Phosphates	0.355	0.265	0.285	1.315	1.525	0.725	307.61	2.43**
Sulphates	30	28.5	26.405	53.125	60.5	34.025	245.69	1.07
Suspended Solids	15.75	8.25	20.875	44.875	57.5	29.81	182.27	1.6
Hardness	112.25	90	67.895	135.5	142	43.21	41.69	0.57
Turbidity	12.27	11.275	6.43	124.64	116.01	105.68	1036.55	2.12**

Significant at 10% p value ** Significant at 5% p value, *** Significant at 1% p value

It is clear that Chromium (IV) , TDS, Conductivity, Calcium, Phosphates and turbidity have increased significantly in downstream water samples. When t test was done to find significant differences in water quality of all treatment samples compared with all control samples, many parameters were found to have significantly increased, such as Copper, Nitrates, TDS, Calcium, Hardness, Turbidity, conductivity, phosphates and suspended solids. (Refer to Table 6)

Table 6: Control vs treatment impacts

Parameters	Control			Treatment			Impact of Industries	Test of mean difference
	Mean	Median	Stdev	Mean	Median	Stdev	(% change in quality)	T-stat
Conductivity	169.84	141.225	89.415	322.165	338.325	116.87	108.39	2.07**
Chromium	0.005	0.005	0.005	0.065	0.075	0.05	1326.67	2.48***
Copper	0.02	0.015	0.015	1.145	1.175	0.19	12990	11.88***
Nitrates	0.895	0.67	0.685	9.575	8.77	5.085	1520.71	3.38***
pH	7.26	7.01	0.415	7.54	7.875	1.065	4.01	0.54
TDS	83.875	83.2	2.28	135.565	141	16.82	61.19	5.26***
Aluminium	0.275	0.275	0.21	0.155	0.155	0.31	-17.21	0.79
Calcium	43	39.5	14.08	126.665	105	41.485	196.14	3.30***
Chloride	0.3	0.125	0.41	0.605	0.705	0.37	424.58	1.09
Iron	0.465	0.48	0.315	0.59	0.7	0.36	126.8	0.52
Manganese	0.915	0.325	1.42	0.095	0.085	0.085	-17.77	1.15
Phosphates	0.565	0.625	0.31	1.01	1.1	0.53	250.03	1.44*
Sulphates	19.5	19	6.055	16.375	16.75	6.92	-11.87	0.67
Suspended Solids	7.875	6	7.995	66.75	46.75	75.65	4961.55	1.55*
Hardness	63	64.75	14.3	99	105.75	19.77	58.55	2.95***
Turbidity	6.75	5.75	7.51	106.005	77.885	64.14	6998.48	3.07***

* Significant at 10% p value, ** Significant at 5% p value, *** Significant at 1% p value

From Table 5 and Table 6 it is evident that water quality has worsened when upstream water quality is compared to downstream and when control compared with treatment, indicative of the effects of industrial effluents being released into them. Water quality was further compared with South African water quality guidelines for fitness of use for livestock, irrigation, domestic and recreational use; the findings were as shown in Table 7.

Table 7: Fitness of water for the above uses in the waterways sampled

Parameters	All control samples mean	All treatment samples mean	Livestock (L) Standard	Irrigation (I) Standard	Domestic (D) Standard	Recreation (R) Standard	Control (standards exceeded)	Impact of Industries Treatment
Aluminium (mg/l)	0.725	0.55	d" 5	d" 5.0	d" 0.15		D	D
Calcium (mg/l)	75	141.4175	d" 1000		d" 32		D	D
Chloride (mg/l)	0.3775	0.3475	d" 1500	d" 100	d" 100			
Chromium IV (mg/l)	0.0125	0.1	d" 1	d" 0.1	d" 0.05			I,D
Conductivity (µs/cm)	289.78	589.00		d" 400	d" 700			L ,I
Copper (mg/l)	0.25	0.73	d" 0.5	d" 0.2	d" 1		I	L, I
Iron (mg/l)	11.015	20.94	d" 10	d" 0.2	d" 0.1		L,I,D	L,I,D
Manganese (mg/l)	0.7525	0.2425	d" 10	d" 0.02	d" 0.05		I, D	I, D
Nitrates (mg/l)	2.37	6.6175	d" 100	d" 5	d" 6			D, I
pH	6.81	7.3925	6.5 - 8.5	6.5 - 8.4	6 – 9	6.5 - 8.5		
Hardness	87.625	117.25			50-100		D	D
Phosphates	0.46	1.1625			0.02		D	D,
Sulphates (mg/l)	24.75	34.75	d" 1000		d" 200			
Suspended	11.8125	55.8125		d" 50				I
Solids (mg/l)								
TDS (mg/l)	140.3225	331.1175	d" 1000	d" 260				I
Turbidity (NTU)	9.51	115.3225			d" 1	d" 5	D,R	D,R

Control water quality has exceeded international standards in some parameters, however water quality of treatment samples showed parameters in excess of more standards and worsening the parameters which had already exceeded standards.Thus making the water unfit for certain uses.

Table 8 illustrates the possible impacts of using the water for livestock, irrigation, domestic and recreational uses, when the parameters exceed standards for fitness of use (due to industrial effluents).

Table 8: Effects of parameters worsening on water use for livestock, irrigation, domestic and recreational uses [2]

Parameters exceeding standards due to industrial pollution	Possible negative effects due to standards exceeding		
Conductivity – L,I	Livestock use Palatability	Irrigation use Reduction in crop yield water evaporates it leaves an impermeable crusty layer on the soil this leads to overall soil structure damage Yellowing of leaves	Domestic and recreational use
Chromium IV – I ,D		Crop yield affected by crop sensitivity to chromium uptake through plant roots Crop quality as determined by chromium toxicity to consumers	Carcinogenic Skin irritation, chrome ulcers retarded foetal development and embryo- and foetotoxic effects including reduced foetal weight, reduced number of foetuses (live and dead) , and higher incidences of stillbirths
Copper – I, L	Diarrhoea, liver damage Gastrointestinal irritation, nausea	Crop yield affected Copper toxicity in plant species	
Nitrates - D			Methaemoglobinemia Palatability Gastroenteritis Irritation of mucous membrane
Suspended Solids		Clogging of drip irrigation emitters Crop yield affected (suspended solids reduce photosynhetic activity, marketability affected due to deposits) Reduction in infiltration rate or seedling emergence due to soil surface crust deposition Clarity of water	
Hardness – D			Lathering of soap, Palatability, Scaling
Calcium- D			Palatability, Scaling problems, Lathering of soap
Iron- L,I,D,R	Liver and pancreas damage, Diarrhoea, Toxicity from high concentrations	Crop yield affected by iron deposits Iron precipitation clogs irrigation equipment	Palatability Slimy coatings –plumbing

[2] (source: South African Water Quality Guidelines,1996)
D – Domestic use, L – Livestock watering, I – irrigation use, R – Recreational use

Manganese	Livestock–lethargy, decreased feed intake, Loss of coordination, diarrhoea	Staining, palatability
Phosphorous –D		kidney damage and osteoporosis

The water quality analysis clearly indicates significant worsening of parameters downstream of industries and in treatment samples as compared to upstream and control water samples. This can be inferred to the effects of industrial effluents being released into the environment and the water bodies.

3.3 Areas of further research

The major limitation of this research has been that it focussed only on the chemical characteristics of water quality. Chemical monitoring only gives the water quality at that moment in time, however biological monitoring gives conditions over an extended period of time.

The following areas have been identified for further research

1. Ongoing Environmental Monitoring: the type of effluents being released into the waterways differ on a day to day basis depending on the type of orders of clothing the industries process. Hence there is need for ongoing monitoring, especially due to current lack of proper datasets. Monitoring of pollution may include parameters not covered in this research which are:
    - Biological monitoring
    - Toxic components such as arsenic, lead, cadmium and other heavy metals.
    - Fertilizers and pesticides
    - COD, BOD
    - Faecal coliform count

2. Groundwater quality assessment in industrialized areas: Industrial and agricultural chemicals and organic pollutants are significant sources of groundwater pollution, which is an area of further research
3. Epidemiological studies that examine effects of pollution on human health. Relationship between long-term exposure to contaminated water and incidence of cancer , skin ailments and other diseases may be looked into. Follow up studies on health impacts of pollution need to done on priority considering the possible implications of some of the pollutants (especially ones which are carcinogenic).

4. Cost-benefit analysis of industrialization versus environmental degradation and negative impact on health and livelihoods.

3.4 Limitations of study

This study has the following limitations

1. Chemical analysis of water quality was done, however biological analysis was not done. Chemical analysis gives the status of the water at that point in time, but biological monitoring gives the status of water over a period of time and is a better indicator of extent of pollution
2. Exact economic implications of pollution for the community and the country at large were not done. Only the cost of purchasing additional water was recorded.
3. Sample size of water samples was limited due to budgetary and time constraints. Water samples were taken after the rains.

Chapter Four

Conclusions and Recommendations

It may be concluded that water quality in the waterways of Lesotho have been affected by industrial effluents being released into them. Community members of lower income category living near these waterways have been affected by the pollution and it has altered their water usage pattern as well as livelihoods for some. Water quality analysis has found some parameters in excess of international standards which may have negative effects if used for livestock, irrigation, domestic use and recreational use.

It is recommended that development Acts such as AGOA should integrate environmental compliance as a mandatory requirement when industries come to host countries such as Lesotho.
It is further recommended that industries with pollution mitigation measures, be given incentives for their efforts for cleaner and greener production.
Health impacts of pollution has been identified as a follow up study to this research which needs to be conducted as a matter of priority.

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