Natsurv 13:

Water and Wastewater Management in the Textile Industry

(Edition 2)

M. Le Roes-Hill, C. Muanda, J. Rohland,
K. Durrell

WATER RESEARCH COMMISSION

TT 724/17

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(EDITION 2)

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Biocatalysis and Technical Biology Research Group,
Institute of Biomedical and Microbial Biotechnology,
Cape Peninsula University of Technology

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Obtainable from

Water Research Commission
Private Bag X03
Gezina 0031
South Africa

orders@wrc.org.za or download from www.wrc.org.za

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Executive summary

The NATSURV 13 document forms a part of a series of national survey documents that are focused on the water use and wastewater management practices of various industries in South Africa. This second edition of NATSURV 13 aims to update the information that was presented in the 1993 survey document, specifically focusing on the water use, wastewater management, energy use, as well as the energy management practices in the South African textile industry.

The information presented in this document was obtained via desktop research, site visits, and questionnaires (hard copies and using "Survey Monkey" software). To determine whether there have been any changes in the industry since 1993, the information obtained was compared to the data presented in the previous survey. In the case of the textile industry, there have been significant changes in the industry since 1994; the industry has moved away from a focus on general apparel to mostly technical textiles, and many companies have consolidated different process steps, combining raw material processing, dyeing, and the production of the final textile-based product.

The main conclusions that were drawn from this survey, were:

1. Specific water intake (SWI) varies with the type of processes and materials used by different companies. It is therefore impossible to suggest specific targets for the industry as a whole. Individual companies should set these targets themselves. However, the different SWI reported in this survey, differ from the average SWI reported in 1993, indicating a decrease in the intake of water.
2. Wastewater generated typically equates to 100% of SWI – this finding is similar to what was reported in the 1993 survey.
3. The range of chemical oxygen demand values reported in this survey was lower than the average reported in 1993, indicating that the implementation of best practices around the use of chemicals has had an effect on the quality of the effluent generated.
4. Similar pH ranges were reported in both the recent survey and the 1993 survey.

Best practices guidelines for the textile industry are also presented in this document. During the survey, different attitudes to best practices were encountered; some companies indicated that implementing best practices is not a priority as long as the final products are produced, while others have implemented extensive best practices programmes, recycling excess waste, taking part in industry symbiosis programmes, and making use of alternative energy sources to minimise the need for electricity supplied from Eskom. Many companies have also indicated a move towards the implementation of ISO 14001 and the use of non-hazardous chemicals.

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- The Water Research Commission for funding the project
- The Reference Group members for their guidance and recommendations
- The regulators who provided input into the formulation of the NATSURV 13 document and for providing data on pollution loads

In addition, the project team wishes to acknowledge the textile companies who participated in this study and their willingness to assist with the production of this updated NATSURV 13 document.

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List of Abbreviations

BOD	Biological oxygen demand
CCTC	Cape clothing and textile cluster
CFTL SETA	Clothing, footwear, textiles and leather sector education training authority
COD	Chemical oxygen demand
CSIR	Council for Scientific and Industrial Research
DWS	Department of Water and Sanitation
IFC	International Finance Corporation
IWRM	Integrated Water Resource Management
J	Joules
KZN CTC	KwaZulu Natal clothing and textile cluster
kWh	Kilowatt hour
NATSURV	National survey
NRDC	Natural resources defence council
SA	South Africa
TexFed	Textile Federation of South Africa
UNEP	United Nations Environment Programme
USDA	United States Department of Agriculture
WISP	Western Cape Industrial Symbiosis Programme
WRC	Water Research Commission
WTO	World Trade Organisation
ZDHC	Zero discharge of hazardous chemicals programme

Section 1: Introduction

Manufacturing and processing industries consume significant quantities of energy and water. In addition, unwanted liquid, solid and gaseous waste is generated along with the intended products. Novel, more sustainable methods are constantly being sought to reduce industrial pollutant loads and re-use water and waste. This move is largely in response to interrelated factors, including higher costs of waste disposal, more stringent legislative requirements, and increasing environmental awareness.

Between 1986 and 2001, the Water Research Commission (WRC) of South Africa (SA) commissioned 16 national surveys (NATSURVs) of various agricultural and non-agricultural industries (1: malt brewing; 2: metal finishing; 3: soft drink; 4: dairy; 5: sorghum malt and beer; 6: edible oil; 7: red meat; 8: laundry; 9: poultry; 10: tanning and leather finishing; 11: sugar; 12: paper and pulp; 13: textiles; 14: wine; 15: oil refining and re-refining; and 16: power generating). The surveys resulted in the publication of 16 separate NATSURV documents, one for each industry. One of these, entitled "Water and wastewater management in the textile industry" (WRC Project No. 145, TT 50/90, 1993), included information about production processes, water usage, solid waste generation, and wastewater quality, quantity and treatment practices in the SA textile industry. The WRC subsequently funded project TT-139-00, resulting in the publication of a waste minimisation guide for the industry (Barclay and Buckley, 2002).

Over the past two decades, the South African textile industry has seen extensive changes and this new survey serves to update the content of the original document. The report includes information stemming from an audit of the industry from both a local and global perspective. Information about the local textile industry was obtained using combined desktop, site-visit, and laboratory-based approaches. In addition to water and wastewater management, the document will include basic energy audits and a report on adoption/non-adoption of sustainable procedures by the industry at large.

The objective of this document is to serve as a comprehensive guide and benchmark tool for local governments, industry players, academics, researchers and engineers. Only textile processing facilities are included, i.e. upstream processes (e.g. the manufacture of products) and downstream processes (e.g. the cultivation of cotton or the farming of sheep) are not included, but are briefly explained in the introduction section.

The methodology employed for data collection consisted of desktop studies (especially for accessing data on international trends, best practices, and the distribution of textile companies in SA), site visits, and the distribution of a questionnaire (in Word format, as well as in the form of a questionnaire using "Survey Monkey" software).

A database of textile companies in SA was compiled based on information obtained from the following sources:

- the Clothing and Textiles Technology Station at Cape Peninsula University of Technology (CPUT)
- the 7th African Clothing and Textile Trade Source Directory (2015)
- the Textile Federation of South Africa (TexFed)
- the South African technical textile cluster
- the Cape clothing and textile cluster (CCTC)
- the KwaZulu Natal clothing and textile cluster (KZN CTC)
- the Cape mohair value chain cluster.

The companies were broadly grouped into three main areas: dyers and finishers, producers, and technical and traditional textiles. To facilitate the process of site visits and requests to complete questionnaires, companies were contacted telephonically and those who expressed an interest to participate in the study were sent an introductory letter from the WRC (Annexure 1) and the questionnaire (Annexure 2). Thereafter, site visits were requested and the completed questionnaires collected. Information obtained from the questionnaires and the "Survey Monkey" questionnaires were collated and the information compared to that presented in the previous NATSURV 13 document (WRC, 1993).

1.1 An overview of the South African textile industry

Over the past two decades, the textile industry in SA has experienced dramatic changes. Pre-1994, the industry was geared towards meeting the needs of the domestic market, but when SA joined the World Trade Organisation in 1994, the country opened up to international trade and had to compete on a global scale. The weakening of the rand and a sudden influx of low-cost imported goods (mostly from China and India) left the industry vulnerable (Vlok, 2006). Correspondingly, there was a dramatic drop in employment levels. In 1990, the industry employed a workforce of almost 100 000 workers; in 2012, the employment level was down to 32 300 (Brink, 2013). Various incentive programmes by the SA government, the development of sector education and training authorities (e.g. the Clothing, Footwear, Textile and Leather Sector Education Training Authority or CFTL SETA), and the establishment of clothing and textile clusters (the KZN CTC, the CCTC, and the South African technical textile cluster), have brought a degree of stabilisation to the industry.

It is therefore not surprising that the past two decades has seen multiple factory closures and an increase in the number of micro-enterprises, home industries and unregistered firms. Many of the companies have also consolidated some of the processes so that the entire process for textile production, from the processing of the raw material until the production of the final product (yarn, woven or non-woven fabric, dyed and printed fabrics and carpet manufacture) takes place on-site. The establishment of the clothing and textile clusters played a key role in driving competitiveness and the upgrading of processes. In addition, the textile industry also started to focus more on niche markets, moving away from the production of textiles for apparel (negatively impacting the clothing sector) towards the production of industrial, technical, and household textiles (Morris and Reed, 2008).

1.2 Defining the textile industry

In literature, when reference is made to the textile industry, other industries such as the clothing manufacturing, leather and footwear industries are often included. For the purpose of this report, the textile industry will be defined as the industry that consists of companies that are involved in the manufacture and processing of textiles through various processes: the production of yarn from natural raw materials (e.g. cotton, wool, mohair) and/or man-made fibres (e.g. viscose, rayon); the production of woven or knitted fabrics from spun yarn; the dyeing and printing of fabrics; and the application of finishing processes (e.g. the production of technical textiles or textiles with industrial applications).

1.3 Materials used in the manufacture of textiles

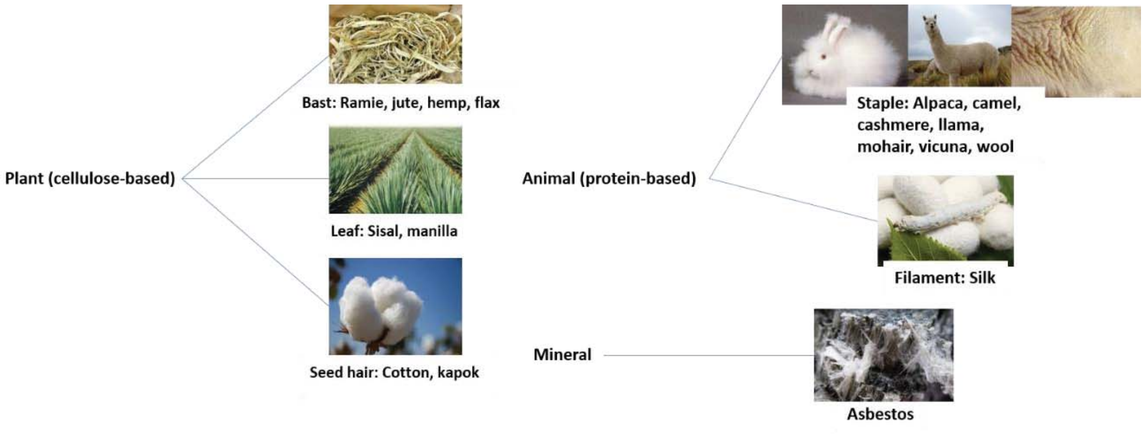
The materials that are used in the manufacture of textiles include various types of fibre (typically grouped into "natural" and "man-made"; Figure 1), chemicals (including dyes), and additives. Each of these will be discussed briefly.

1.3.1 Raw materials: fibres

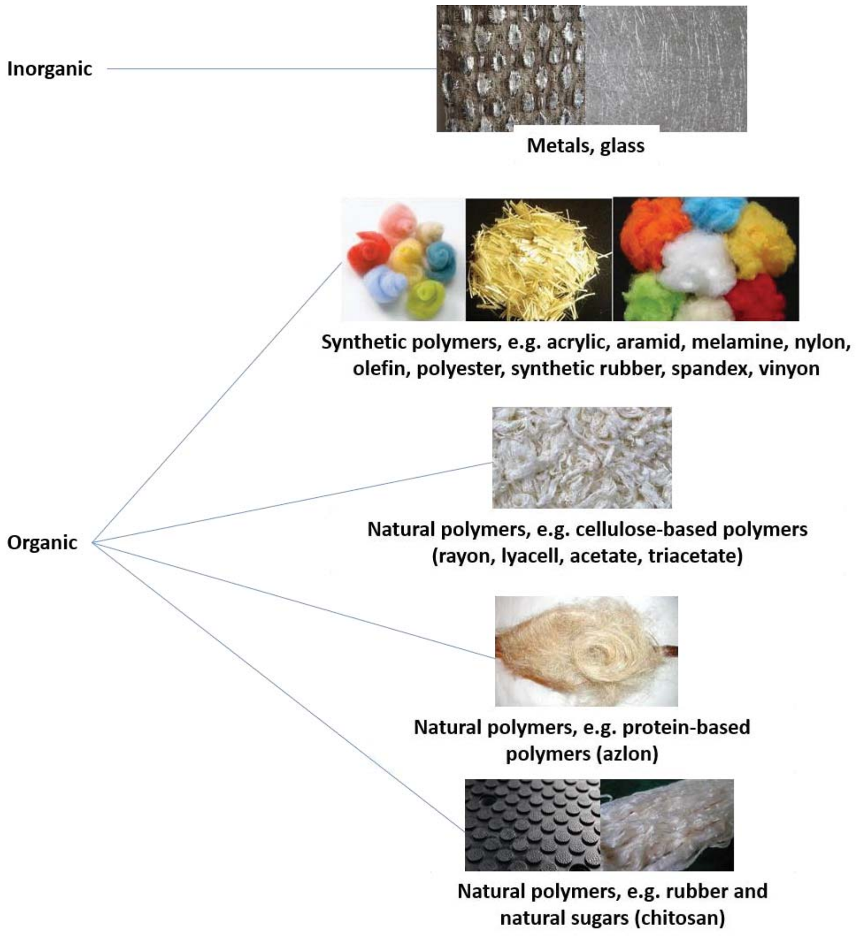
The South African textile industry mostly uses cotton, wool, mohair, jute and sisal (natural), and various synthetic, man-made fibres, e.g. polyester, nylon, acrylic, viscose and polypropylene. According to *Brand South Africa* (www.brandsouthafrica.com), SA has steadily been increasing its output in the production of synthetic fibres, especially for the production of technical textiles.

1.3.1.1 Cotton

Cotton is a soft, protective, cellulosic fibre that grows around the seeds of cotton plants (genus *Gossypium*). It is one of the most common raw materials used in the production of textiles. Lint from the seed cotton is typically processed directly for textile production, while seed linters may also be processed into felts (for upholstery), yarns (for twines, mops and rugs), absorbent cotton medical supplies or pulp. The pulp in turn can be processed for the production of viscose and cellulose acetate (synthetic fibres) for application in the textile industry (www.cottonsa.org.za). According to the United States Department of Agriculture, SA's total cotton production for 2014/2015 was approximately 19 000 metric ton, which constituted 0.07% of global production (25 906 000 metric ton). It is estimated that a total of 17 000 metric ton will be imported in 2014/2015 (mostly from Zambia and Zimbabwe), of which 20 000 metric ton will be consumed domestically, with the remainder being exported (www.cottonsa.org.za). The processing of cotton for the production of textiles is described in Section 2.



(A)



(B)

(C)

Figure 1: Raw materials used in the manufacture of textiles: (A) natural; (B) man-made; and (C) common raw materials used in the SA textile industry (in order of presentation: cotton, wool, mohair, silk, and synthetic fibres)

1.3.1.2 Wool

In SA, the majority of wool is obtained from Merino sheep with a small proportion of wool being obtained from Karakuls. Wool fibres are specialised skin cells that grow in clusters (staples), have a crimped appearance, and a unique texture, thereby differentiating wool from hair. SA mainly produces apparel wool. During the 2013/2014 season, more than 50 000 metric tons of greasy wool were produced, of which 63.2% was exported to China, 13.8% to the Czech Republic, 10.3% to Italy, 5.7% to India, 2.7% to Germany, 2.0% to Egypt and 1% to the United Kingdom (Cape Wools; www.capewools.co.za).

1.3.1.3 Mohair

Mohair is obtained from the Angora goat, which in SA is farmed in the Karoo area of the Eastern Cape. It is considered to be a high-end, luxury, animal fibre and is solely aimed at the apparel industry. According to Mohair SA (2013), SA is the biggest supplier of mohair to the global market (53%), followed by Lesotho (18%), Argentina (11%), Turkey (6%), Australia (4%), USA (3%), and New Zealand (1%). The processing of mohair is very similar to that of wool, but with more care being taken to produce a softer final product.

1.3.1.4 Silk

SA is not considered to be a global competitor in the production of silk. Africa Silks is a company that started in 1998 and is involved in the production of silk and silk products. It has expanded across two farms in Mpumalanga where silk is produced by the Mulberry silk worm (*Bombyx mori*). The company is also responsible for the processing of the silk for the production of reeled and spun silk. It involves local communities and has expanded to include eight nationwide outlets for the retail of silk products (www.africasilks.com).

1.3.1.5 Synthetic fibres

As can be seen in Figure 1, a vast array of synthetic fibres is currently being used by the textile industry. In most cases, the use of synthetic fibres is driven by the fact that these fibres are stronger, easier to care for, abrasion-resistant, inexpensive and easily available, compared to natural and regenerated fibres. Some examples of synthetic fibres that are produced in the SA textile industry include the following: nylon 6.6 is used in the production of parachutes, paragliders and hot air balloons (www.airotec.co.za); polyester is used in the manufacture of products used in military, school, medical, hospitality, and corporate apparel (www.gelvenor.co.za/brands/granite); and polyamide is used in the manufacture of breathable materials used in sports and outdoor apparel (www.gelvenor.co.za/brands/qantec). Innovative research is taking place at the Council for Scientific and Industrial Research (CSIR) for the development of new types of fibre (e.g. polymer and natural fibre composites) that can be used in the production of textiles. In addition, the use of electro-spun nanofibres, a new type of synthetic fibre, is also being explored for its application in the production of medical textiles (www.csir.co.za/msm/fibres_and_textiles/overview.html).

1.3.2 Raw materials: chemicals and other additives used in the textile industry

Chemicals that are used in the production of textiles include acids, alkalis, bleach, dyes, salts, size (e.g. starch), stabilisers, surfactants, and additives used during the finishing processes such as flame retardants (Entec, 1997). These chemicals result in the generation of effluent with high chemical oxygen demand (COD), biological oxygen demand (BOD), variable pH levels, variable levels of salts and metals, and colour. In addition to their contribution to colour in textile effluent, dyes can be persistent and may not be removed by conventional treatment processes. According to the SA Dyers' and Finishers' Association, the SA textile industry most commonly makes use of the following types of dye: reactive dyes, vat dyes, sulphur dyes, some direct dyes (more common in the paper industry), and disperse dyes. Acid and basic dyes are used on a smaller scale, while the use of indigo dyes is being phased out, mainly because South Africa no longer makes denim fabric. In addition, most companies are moving away from the use of azo dyes and mordant dyes due to their health and environmental impact. In 2015, major international brands came together to develop a "manufacturing restricted substances list". The list was published to assist textile companies in selecting chemicals that would lead to obtaining a "zero discharge of hazardous chemicals" (ZDHC, 2015). It is highly recommended that SA textile companies include this approach in the development of environmental sustainability programmes.

1.4 Applications of textiles

There are thousands of different applications of textiles (Figure 2), each of which would define the composition of the textile (natural, blend, synthetic) and how it was prepared during processing. For example, the finishing processes applied to technical textiles are different to those applied to textiles destined for the clothing/apparel market. It is therefore clear that different types of processes and equipment would be required (covered in detail in Section 2).

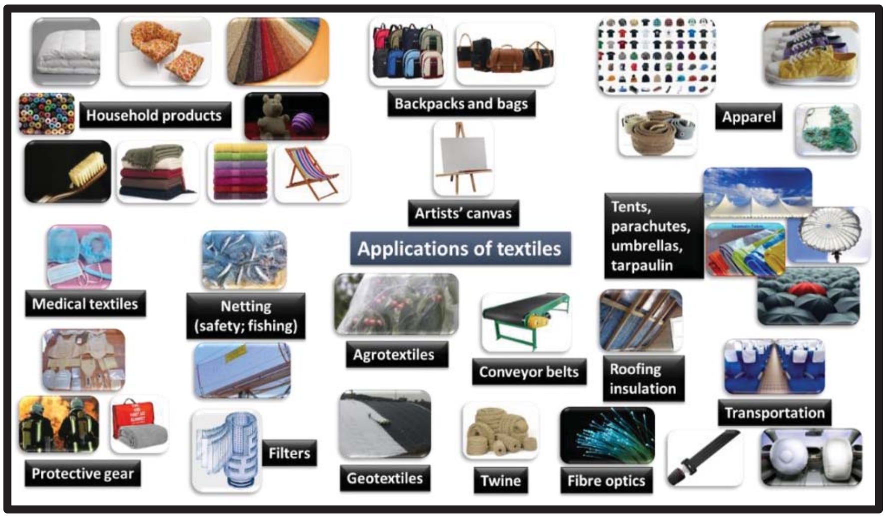


Figure 2: Selected examples of the applications of textiles

1.5 Global and local trade of textiles

According to the WTO, textiles only recorded an average annual growth rate of 4% between 1995 and 2014 (WTO, 2015). Looking at SA's profile for the past few years, shown in Figure 3, it is clear that SA imports many more textiles than it exports. However, from 2010 there has been an increase in the number of exports, which is probably due to an increase in trade within the Southern African Customs Union, which was initiated in 2010 (KZN CTC Bulletin 2nd quarter, 2015). According to Statistics South Africa (2015) and as recorded in the KZN CTC Bulletin 2nd quarter (2015), the 2014 financial year showed a revenue increase of 12% in the textile industry, which is further evidence that this industry is starting to stabilise. Figure 4 shows that the textile industry in SA is mostly driven by smaller firms, compared to the international textile industry where large firms contribute significantly to annual revenue. For the SA industry to become more globally competitive, it would have to use international trends for benchmarking or alternatively build on filling niche markets to ensure further growth.

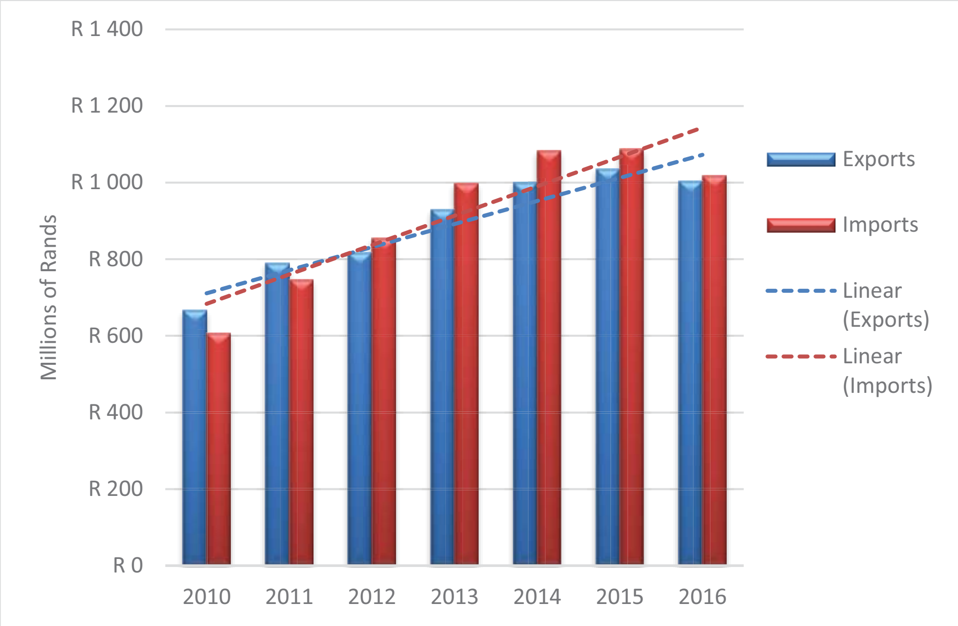


Figure 3: South African trade in textiles (2010-2016) (South African Revenue Service)

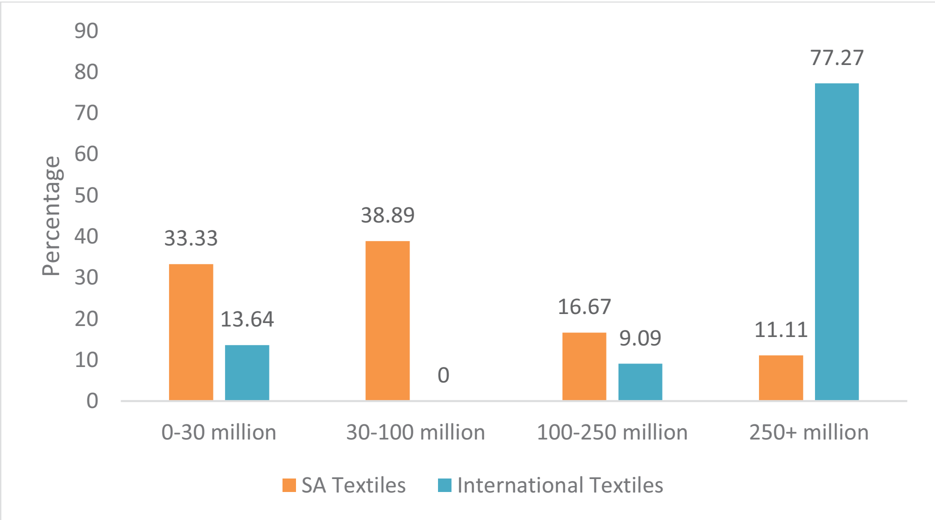


Figure 4: Profile of the SA textiles industry as compared with international textile industries, categorised by annual revenue

1.6 Textile companies/clusters in South Africa

As indicated previously, the textile industry in SA is mainly clustered in the Western Cape Province (37%) and KwaZulu Natal (31%). Various textile industries are also situated in Gauteng Province (21%), the Eastern Cape (9%), Free State (0.5%) and Mpumalanga (1%), but textile production is minor in these provinces compared to the two main clusters. (These percentage values are based on information obtained from the The 7th African Clothing & Textile 2015 Trade Sourcing Directory and may not fully reflect the entire industry, especially those companies that are not registered). The textile companies vary from those involved in dyeing, finishing and washing, to manufacturers and suppliers of yarns and fibres, knitted fabrics, technical textiles, and home textiles, to name a few.

Section 2: Overview of textile manufacturing processes

The processing of raw materials for the production of yarns and/or fabrics may be carried out by various related industries or could be consolidated on one site. A wide choice of natural and/or synthetic fibres are blended and spun to produce the appropriate yarn mixes. Weaving and knitting are two of the common techniques used to make fabrics, which in turn could undergo bleaching, dyeing, printing and/or finishing for the production of textile goods (Figure 5). The textile industry is widely diversified, making simple descriptions and categorisation virtually impossible. However, an attempt of classification can be made with regards to specific purposes. Three types of categorisation can be considered: unit operations, mill types, and processing sequences.

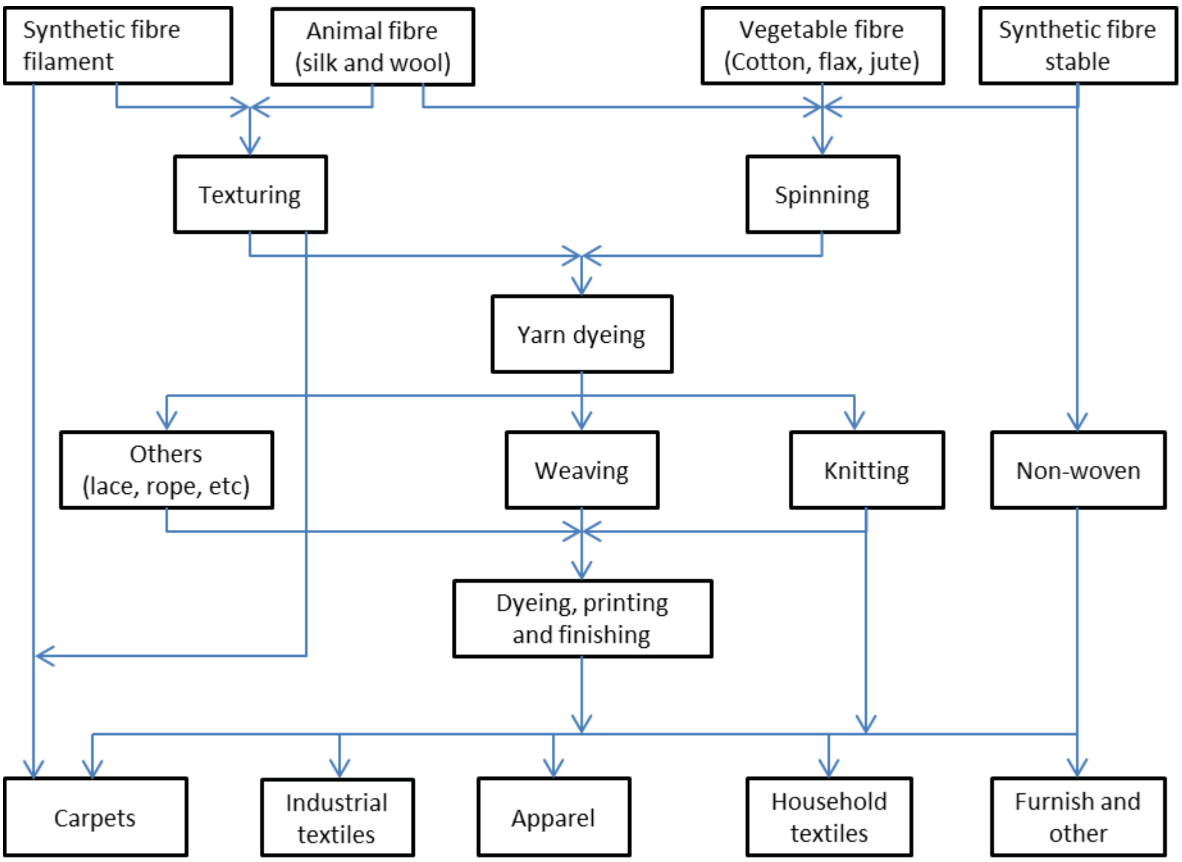


Figure 5: Summary of the overall processing that takes place in the textile industry (adapted from P2ric, 2012)

2.1 Unit operations

The processing of textiles contains many steps that require the use of water. Although the steps are common to various types of fibre, specific water uses vary according to fibre types, the equipment being used, methods, etc. The following is a brief description of the major unit operations that take place in the textile industry:

Opening, picking and blending: during this process, raw fibres are spread open and any impurities present (e.g. seeds or short fibres) are removed. Fibres may be blended at this stage prior to further processing.

Combing and carding: fibres are aligned to ensure that there is a consistency in the length of the fibres. Any imperfections detected are rectified, e.g. short fibres are removed and any other waste is removed.

Spinning: once fibres have been analysed by combing and carding, the fibres are mechanically drawn out and twisted into yarn. The yarn can then be further processed for dyeing, finishing, knitting, or weaving.

Sizing: prior to the weaving of yarn into fabrics, the yarns are covered with a thin coating to protect them from abrasion during the weaving process. The sizing agent also reduces yarn hairiness, and strengthens the yarns. Different types of sizing agents are used in the textile industry and include modified starch compounds, polyvinyl alcohol, carboxymethyl cellulose, or a mixture of these agents.

Weaving: this dry process is conducted under controlled high-humidity conditions in order to increase the flexibility of yarns and minimise yarn breaks on the loom.

Singeing: surface hairiness is removed from woven fabrics through the controlled application of heat.

Knitting: even though this is a dry process, knitting oils are applied to reduce friction and to prevent the breaking of yarn during the knitting process. The oils are eventually removed for further processing.

Desizing: sizing agents can interfere with downstream processes and therefore need to be removed after weaving. Different processes are used during this step, e.g. starch-based sizes are removed using enzymatic degradation, while synthetic sizes are recovered using membrane techniques. Wool cannot be desized, and therefore the sizing agents remain on the fibre.

Dyeing: the dyeing process adds colour and can be achieved by dyeing the raw material, the yarn, or fabric. The dye can be applied either in batch or continuous mode, and can be conducted using different types of equipment, with the fabric either in rope or open–width form.

Printing: the same types of dyestuff as are used during the dyeing process are also used in printing. The dyestuff is applied in a paste form, which is then baked, fixed, and washed off. A wide range of printing methods are used in the textile industry.

Scouring: inherent or added impurities are removed from raw fibres or fabric during the scouring process. It is therefore no surprise that this process results in the generation of wastewater with a high organic loading and therefore high COD and BOD concentrations. Alkaline reagents are typically used during this process, resulting in effluents that are also alkaline and high in sodium. Different fibres undergo different scouring treatments: sodium carbonate and detergents are used for the scouring of wool; cotton is scoured with boiling sodium hydroxide solutions and detergents; polyester is scoured at 60°C and under mild alkaline conditions; and polyester-cotton blends are scoured under intermediate alkaline and temperature conditions.

Mercerising: during this process, cotton fibres (under tension) are treated using concentrated sodium hydroxide solutions. The treatment increases different characteristics of the fibres, including reflectance, dimensional stability, dyeability, lustre and shear strength. The fibres are rinsed and neutralised resulting in effluents that are highly alkaline (pH> 13.5).

Bleaching: the natural colour of yarns and fabrics is removed during bleaching and requires the use of oxidising agents such as hydrogen peroxide or hypochlorite solutions.

Finishing: during the finishing step, the stability and quality of the handle of the fabric is improved through various treatment processes. These treatments can result in a final fabric that is soft and crease resistant, or has special properties such as stain resistance or ultraviolet resistance or flame proofing, or is antibacterial or insect repelling, to name a few.

Carbonising: this process is limited to the treatment of wool where sulphuric acid is used in order to remove any remaining organic matter.

Fulling: the stretch characteristics of material are improved during the fulling process. It is achieved by mechanically working wet wool and through the addition of detergents.

2.2 Types of textile factories

Textile mills vary widely from one another, depending on the process or the fibres involved in the manufacture of the textile goods. The principal types of textile mills are briefly described in the following sections.

2.2.1 Dry processing mill

In SA, dry processing mills (Figure 6) are often situated on the same site as the downstream processing mills. At dry processing mills, spun yarn or woven fabrics are produced from raw fibre stock, and sent either to stock yarn dyeing and finishing, or woven fabric finishing.

2.2.2 Woven fabric finishing mill

At woven fabric finishing mills (Figure 7), fabrics are prepared for dyeing and printing through extensive pre-treatment. Finishing operations are often affected by the type of fibre and its required final properties. Synthetic woven fabrics usually only require softening as their finishing step, while cotton requires a combination of treatments with softeners and resins.

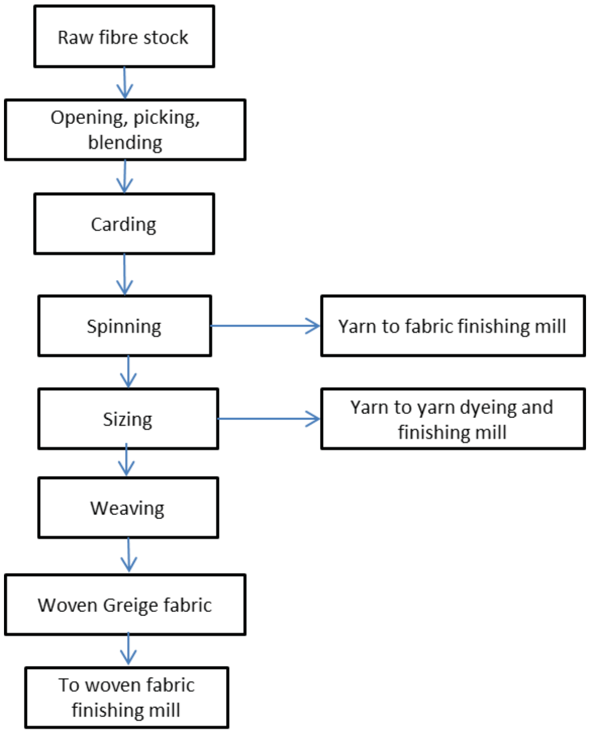


Figure 6: Schematic diagram of a dry processing mill (adapted from WRC, 1993)

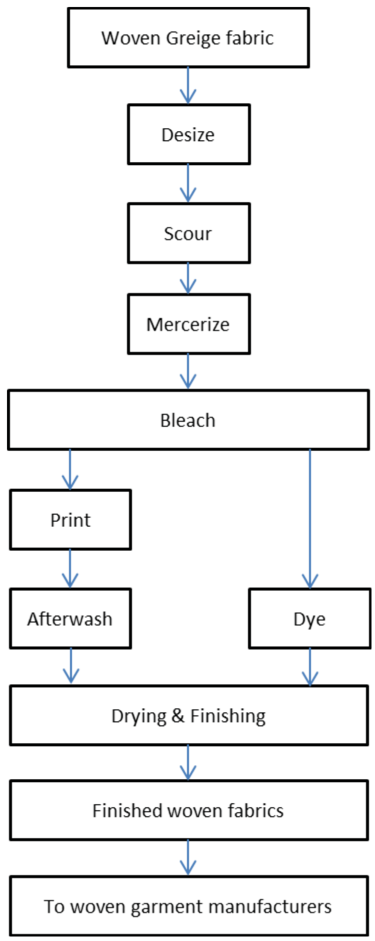


Figure 7: Schematic diagram of a woven fabric mill (adapted from WRC, 1993)

2.2.3 Knit fabric finishing mill

At this stage, knitted cotton fabric is prepared for dyeing and finishing (Figure 8). The preparation is almost the same as for woven cotton. The main differences are the type of equipment required, and the use of softener for finishing. Knitted oil must be removed from the knitted synthetic fabric through a light scouring process before the start of the finishing process.

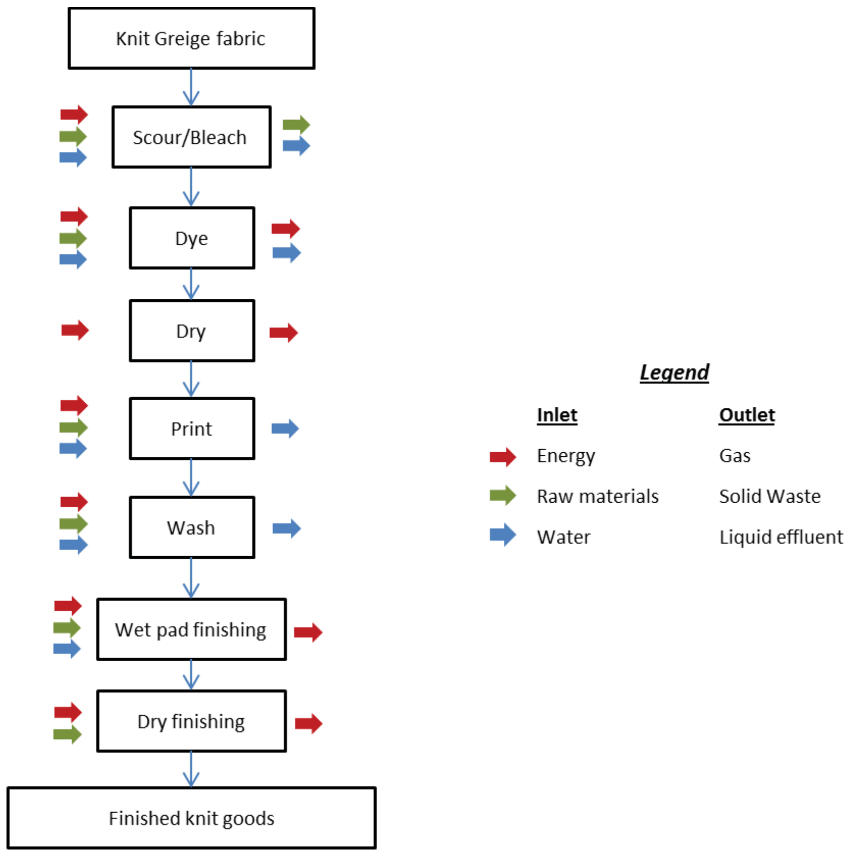


Figure 8: Schematic diagram of a knit fabric finishing mill (adapted from P2ric, 2012)

2.2.4 Wool scouring mill

Raw wool requires scouring because it contains a lot of impurities such as dirt, suint (sweat), grease and vegetable matter. Effluents that are produced from wool scouring mills have very high organic and inorganic pollutant load (Figure 9).

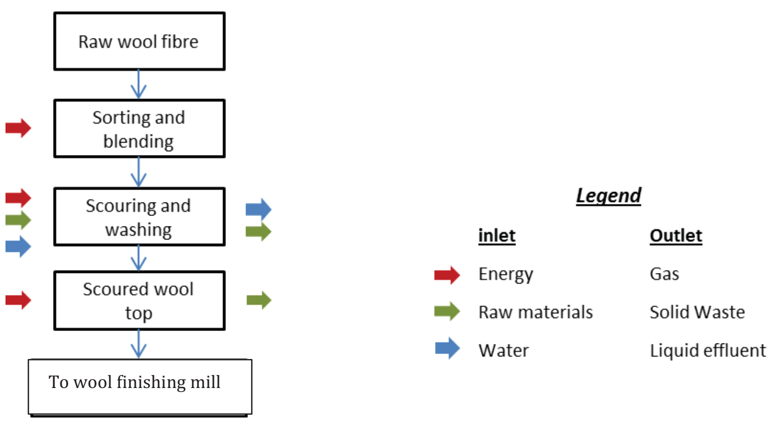


Figure 9: Schematic diagram of a wool scouring mill (adapted from P2ric, 2012)

2.2.5 Wool finishing mill

Most wool finishing mills (Figure 10) produce both 100% woollen goods and materials that are wool-synthetic blends. Wool tops are usually blended and scoured prior to dyeing. Detergents are added to 100% woollen goods for fulling in order to increase the dimensional stability of the material. Worsted and wool-synthetic blends do not require fulling.

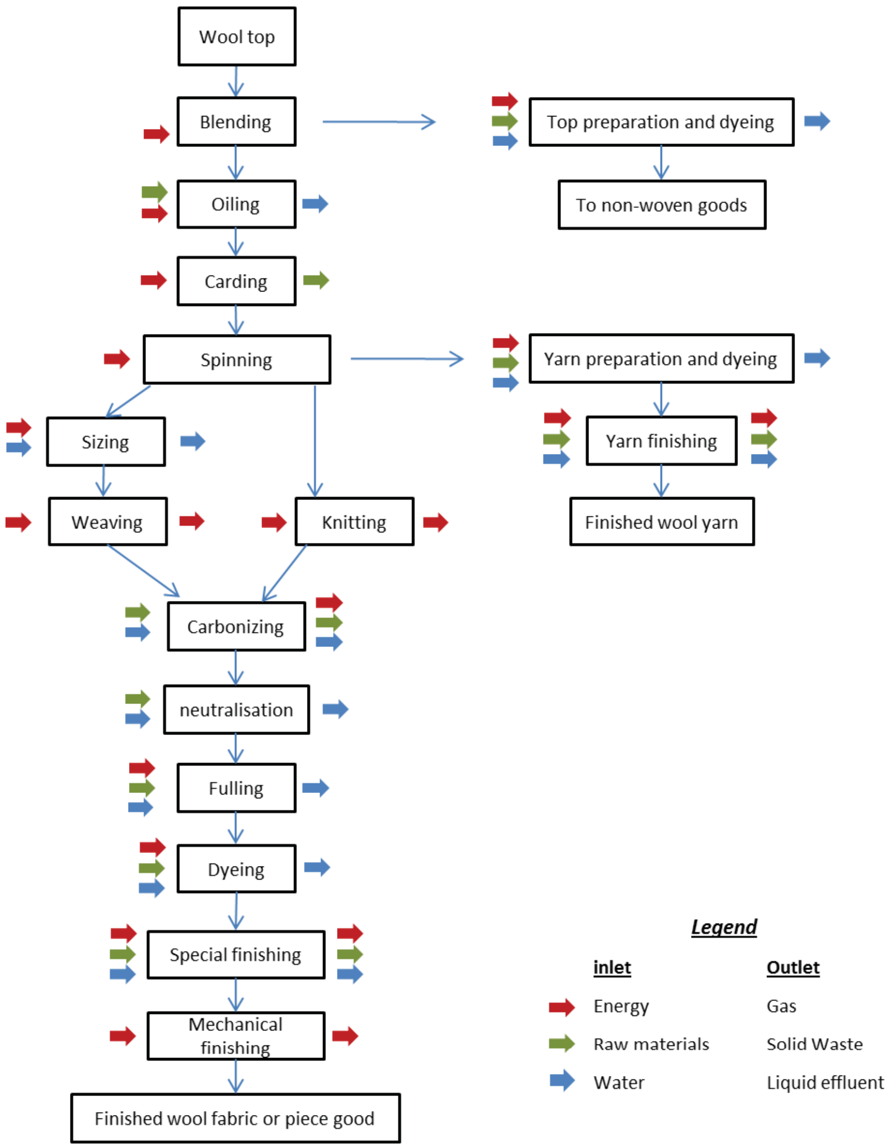


Figure 10: Schematic diagram of a wool finishing mill (adapted from P2ric, 2012)

2.2.6 Stock and yarn dyeing and finishing mill

At the stock and yarn dyeing finishing mills, cotton yarns are bleached, mercerised, dyed and softened; synthetic yarns are dyed with a light colour before being sent to dyeing and softening (Figure 11).

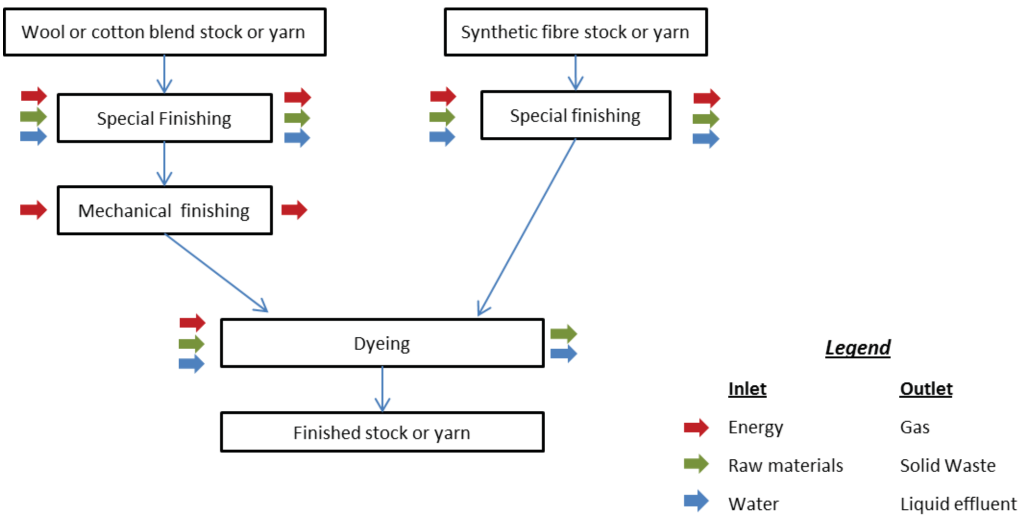


Figure 11: Schematic diagram of a stock or yarn dyeing and finishing mill (adapted from P2ric, 2012)

2.2.7 Carpet mill

Carpets are either dyed and/or printed after weaving using methods appropriate to the type of fibre involved, or woven using pre-dyed yarn (Figure 12). A foam backing is often applied to the carpet for stabilisation after being washed and dried.

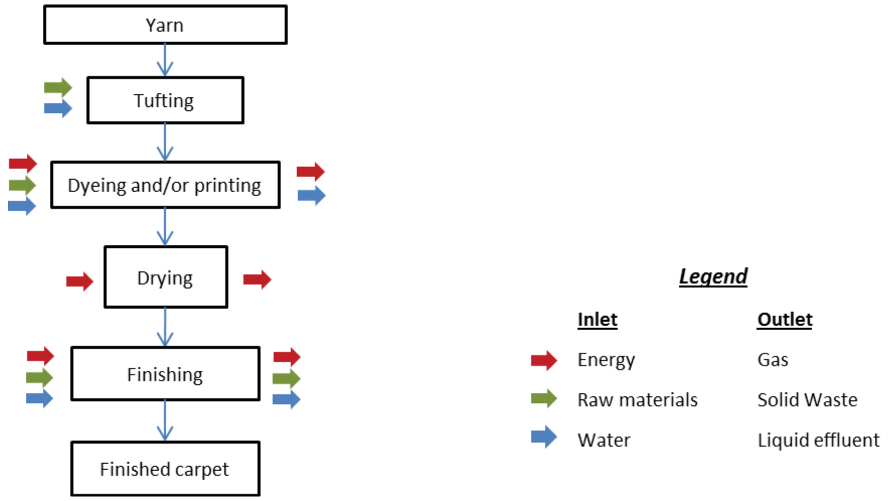


Figure 12: Schematic diagram of a carpet mill (adapted from P2ric, 2012)

2.2.8 Other (dyehouse)

Contract dyehouses conduct dyeing and finishing operations on various types of fibre and fabric types using batch continuous processing methods. Wastewater with a high organic load is generated at these dyehouses and requires treatment before discharge.

2.3 Flow process of the main fibre types

The major steps in the processing of cotton, wool and synthetic materials are shown in Figures 13 to 15. Synthetic materials often produce a wide range of by-products such as polyester, acrylics, viscose and nylon. The COD concentrations during processing, especially in dyeing, vary widely because of differences in the chemical composition of the synthetic fibres. In the production of blended fibres, such as polyester-cotton, the two fibres are either dyed separately, generating two different dyeing wastewaters, or as a blended fibre, producing one effluent. The manufacture of garments and accessories often requires a number of processing steps, that may involve dyeing and finishing, which also affect the quality of the textile wastewater.

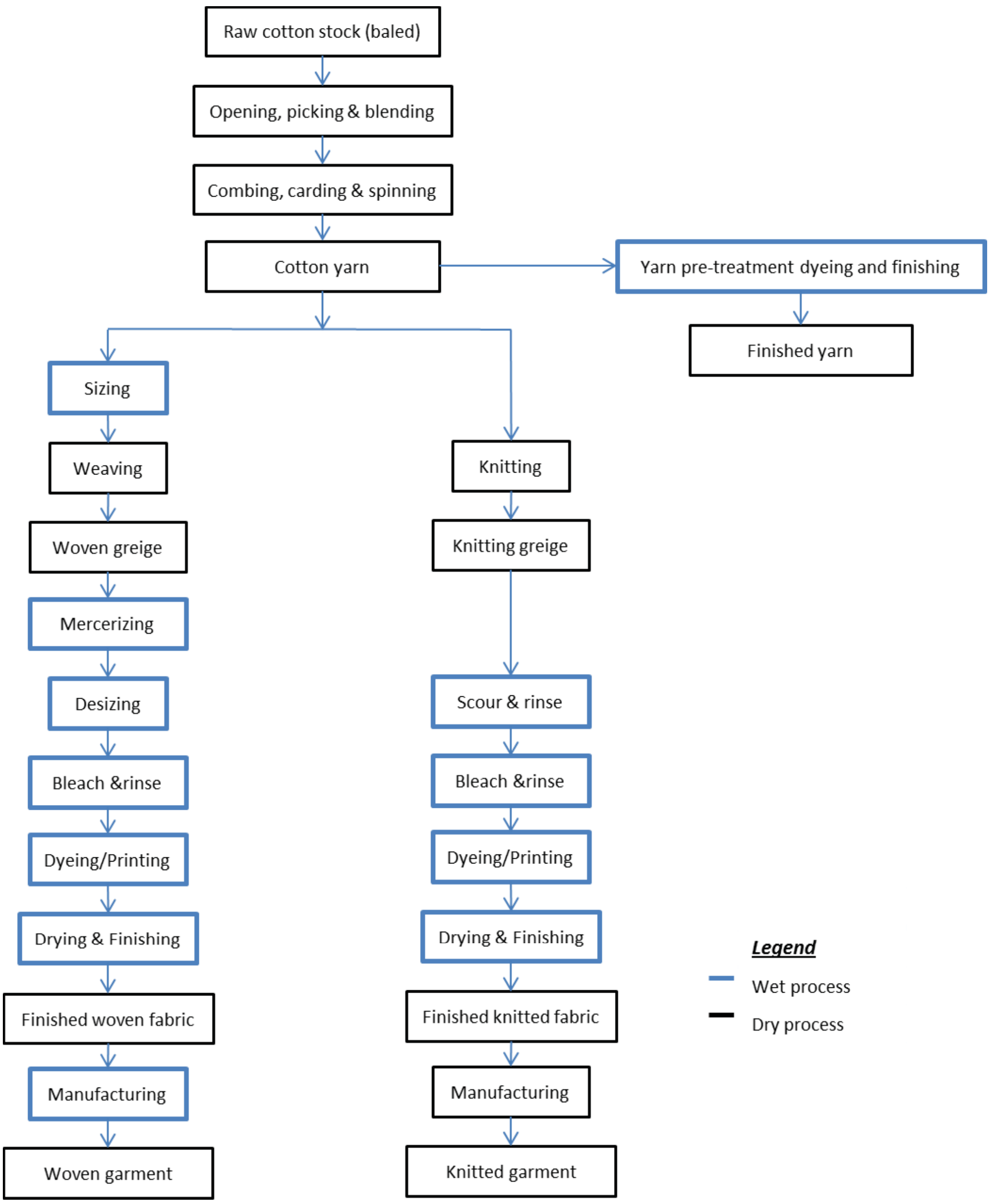


Figure 13: Main steps in cotton processing (adapted from WRC, 1993)

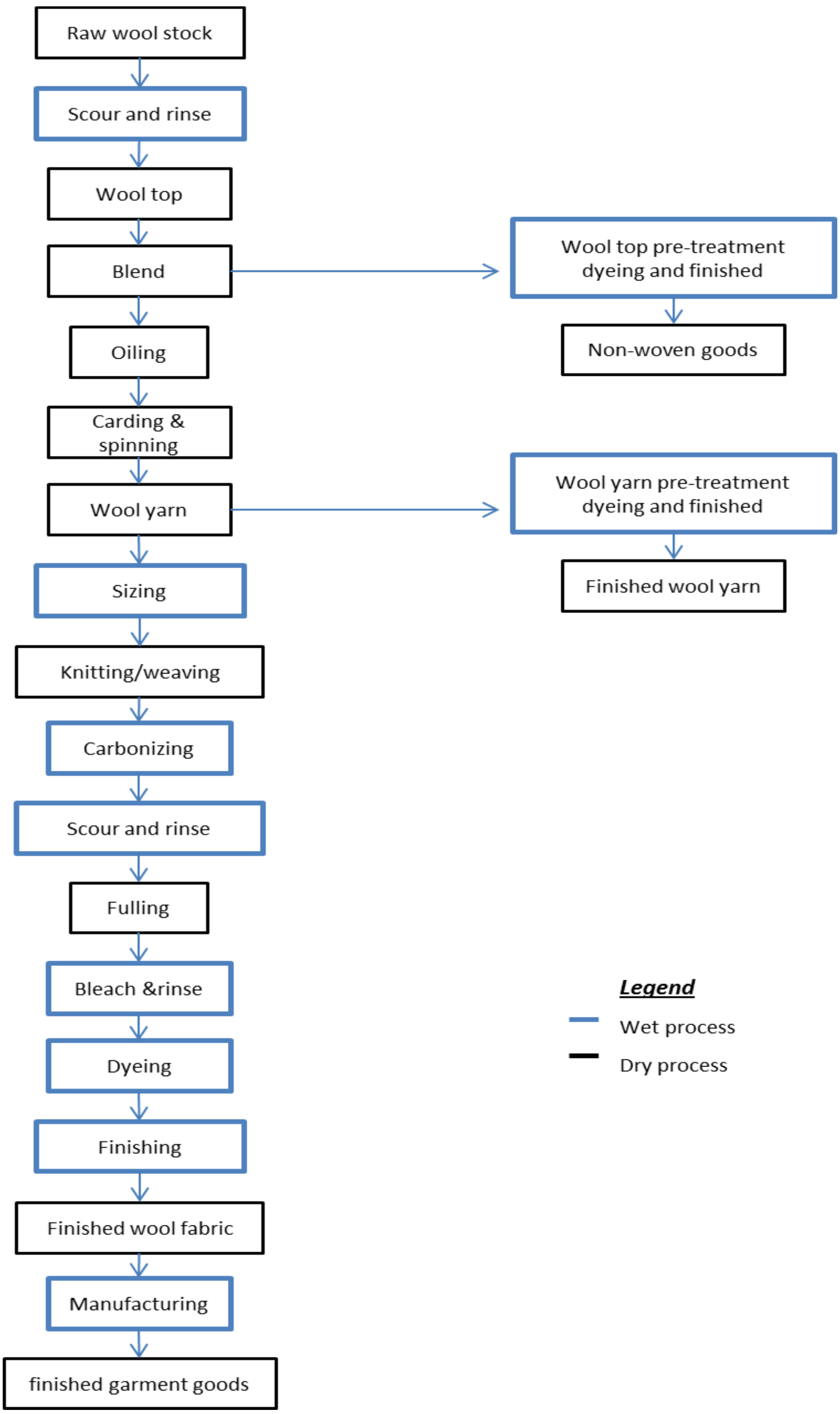


Figure 14: Main steps in wool processing (adapted from WRC, 1993)

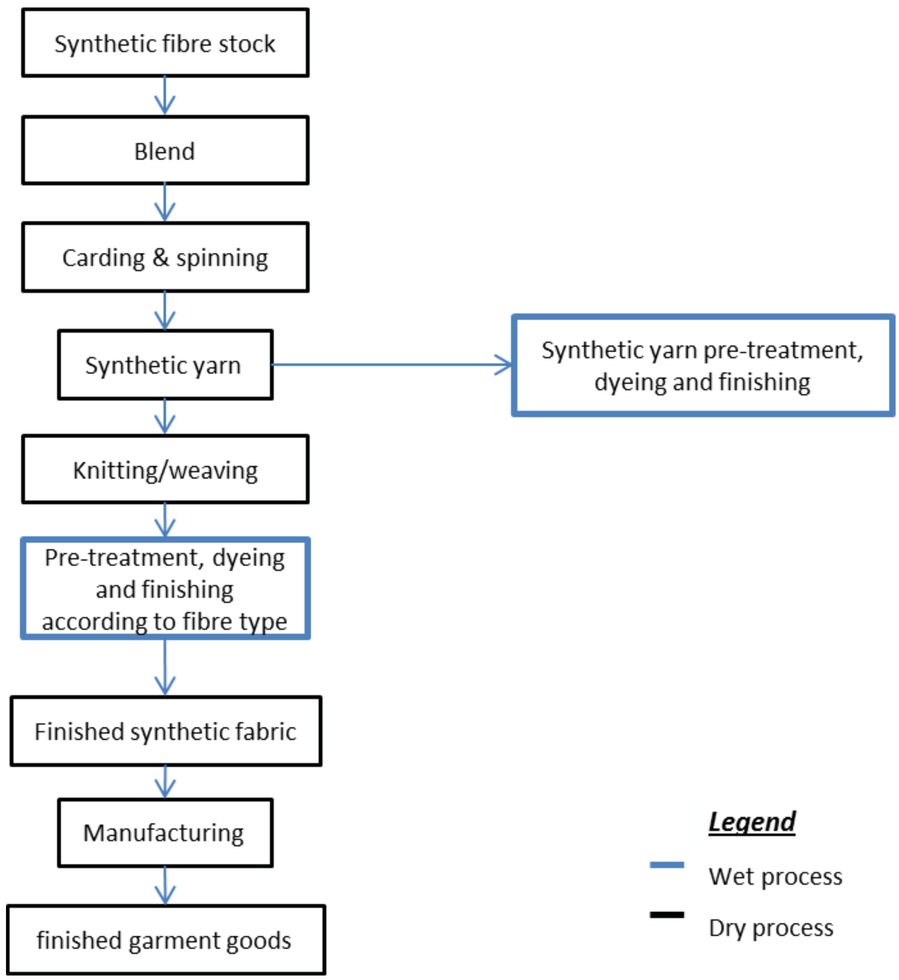


Figure 15: Main steps in the processing of synthetic fibres, yarns and fabrics (adapted from WRC, 1993)

Section 3: Regulations, policies, by-laws and tariffs for water use, wastewater generation, and the environment

South Africa has a three-tier system of government: national, provincial and local government. In general, national government is responsible for high-level security functions, economic regulation and social development. Provincial government is responsible for regional economic planning, housing, environmental management, rural livelihoods and human development, while local government is responsible for basic service provision and for creating an enabling environment for local businesses. The relationship between these three spheres of government is based on a system of co-operative governance as defined in South Africa's Constitution (Act 108 of 1996).

On a local level, governance takes place through municipalities such that all urban and rural areas fall under local municipal control. There are three types of municipalities – metropolitan, district and local municipalities. The largest metropolitan areas are governed by metropolitan municipalities which have exclusive municipal executive and legislative authority in their respective areas, while the rest of the country is divided into district municipalities, each of which consist of several local municipalities. There are eight metropolitan municipalities, 44 district municipalities and 226 local municipalities in South Africa.

3.1 National policies

The Bill of Rights in the Constitution of the Republic of South Africa (Act 108 of 1996) enshrines the concept of sustainability. Rights regarding the environment, water, access to information, and just administrative action are specified in the act. These rights and other requirements are further legislated through the National Water Act (Act 36 of 1998). The latter provides the legal basis for water management in South Africa by ensuring ecological integrity, economic growth, and social equity when managing water use.

The National Water Act introduced the concept of Integrated Water Resource Management (IWRM), which provides for resource and source directed measures to manage the aquatic environment. Resource directed measures aim to protect and manage the environment that receives water, while source directed measures aim to control the impact on the receiving environment by preventing pollution, reusing water, and treating wastewater. The integration of resource and source directed measures forms the basis of the hierarchy of decision-taking aimed at mitigating the effect of waste generation. This hierarchy is based on a precautionary approach and the order of priority for water and waste management decisions and/or actions is shown in Figure 16.

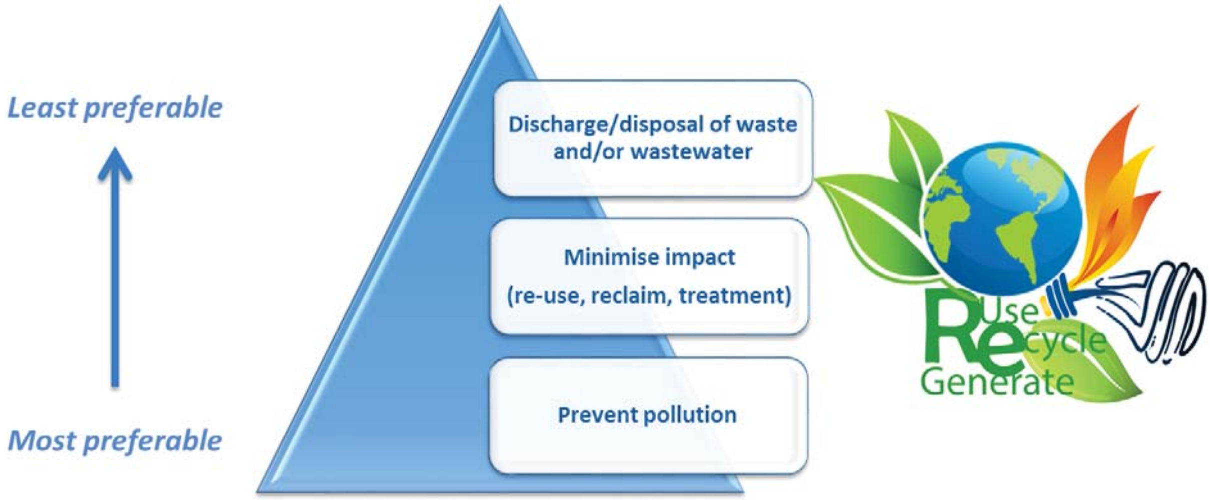


Figure 16: Hierarchy of decision-making to protect water resources

3.1.1 Water policies

The Department of Water and Sanitation (DWS), formerly known as the Department of Water Affairs (DWA) or the Department of Water Affairs and Forestry (DWAF), is the water and sanitation sector leader in South Africa. DWS is the custodian of South Africa's water resources and of the National Water Act, Act 36 (RSA, 1998) and the Water Services Act, Act 108 (RSA, 1997). DWS is also the national regulator of the water services sector.

The National Water Act provides the legal framework for the effective and sustainable management of water resources within South Africa. The Water Services Act deals mainly with water services or potable (drinkable) water and sanitation services supplied by municipalities to households and other municipal water users. It contains rules about how municipalities should provide water supply and sanitation services. Within each municipal area, by-laws are developed which outline the water supply and effluent discharge regulations and tariffs for that area (Section 3.2).

3.1.2 Wastewater policy

Under the National Water Act, norms and standards have been set for the treatment of wastewater or effluent prior to discharge. These consist of general and special standards and set limits for aspects such as pH, temperature, COD, suspended solids, metals etc. The test method that is to be used to determine these levels is also specified. Any industries or municipal or private wastewater treatment works discharging to river or sea must comply with these limits. In turn, the entity operating a wastewater treatment works must set limits for industries discharging to the works such that the DWS final discharge limits can be met.

3.1.3 Environmental policies

The Constitution of South Africa states that everyone has the right to an environment that is not harmful to his or her health or well-being and the right to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development. Regulations that addresses these rights falls under the responsibility of the Department of Environmental Affairs (DEA).

Laws that are most relevant to the textiles sector are the National Environmental Management Act (Act 107 of 1998), the National Environmental Management: Waste Act (Act 59 of 2008), and the National Environmental Management: Air Quality Act (Act 39 of 2004). Broadly speaking, these acts outline the requirements for the storage and handling of waste on-site, licensing requirements, the establishment of waste management plans, the setting of limits for air emissions, and the setting of penalties for offences.

3.2 Municipal by-laws and water and effluent tariffs

The Water Services Act sets out the regulatory framework for institutions tasked with the supply of water services. The act makes provision for different water service institutions to be established as follows:

- The water services authority (WSA) – the responsible municipality
- The water services provider (WSP) – the entity whose role is to physically provide the water supply and sanitation services to consumers.

Municipal units are governed by municipal policies and by-laws for the provision of water and sanitation services, water services development, and sewage disposal. The latter includes the discharge of domestic, commercial and industrial effluent. Tariffs are set for these services at a municipal level, and are generally revised on an annual basis. Any industry wishing to discharge to a wastewater treatment works must apply to the relevant municipality for a trade effluent permit. Trade effluent may not be accepted if it contains concentrations of substances above stated limits, which vary from municipality to municipality. In terms of by-laws, municipalities are entitled to take random or scheduled samples of effluent to ensure compliance with regulations and permits. Different limits may apply to wastewater treatment facilities with different capacities, or for discharge to sea outfalls for coastal municipalities. Depending on local by-laws, requirements for obtaining permits may include stipulations about discharge days and/or times, and requirements for up-front assessments to identify possible means of reducing water consumption and wastewater generation at source. The effluent discharge costs may include punitive fines for non-compliance to stipulated limits. However, many municipalities strive to rather work with industry to attain acceptable water usage and wastewater discharge quality, than to apply punitive measures. Many of the by-laws include chapters advising on various means of conserving water, thereby promoting best practice.

The by-laws and tariffs for the metropolitan municipalities and selected local government municipalities where textile facilities are located are described briefly in this section.

3.2.1 eThekwini metropolitan municipality

Industrial, commercial and institutional customers are charged for the acceptance of sewage into the municipal sewerage system by means of a volume-based sewage disposal charge which replaced sewage rates from 1 July 2010.

In addition, industries which are permitted to discharge trade effluent with a pollution load exceeding that of typical domestic sewage, are charged for disposal according to Equation 1. Data on basic unit costs for water and effluent, and the values for V and Z used in Equation 1 are provided in Table 1.

$$\text{Volume based charge} + V\left(\frac{COD}{360} - 1\right) + Z\left(\frac{SS}{9} - 1\right) \qquad \text{Equation 1}$$

Where:
COD = chemical oxygen demand in mg/L, SS = settleable solids in L/L, V = rate for the treatment of domestic effluent (COD < 360 mg/L), Z = rate for the treatment of domestic effluent (SS < 9 ml/L)

The volume of trade effluent discharged is determined by an effluent meter. If no meter is in place, the volume is determined from a water balance questionnaire which is filled in by the company. The effluent volume is calculated by deducting the volume of domestic effluent, process water, and evaporative losses from the incoming water volume.

Table 1: Basic unit costs for water and industrial effluent – eThekwini metropolitan municipality

Period	Effluent	Effluent	Effluent	Water
	Unit cost (R/kL)	COD charge (V) (R/kL)	SS charge (Z) (R/kL)	Unit cost (R/kL)
2011-2012	5.34	0.57	0.52	12.80
2012-2013	5.68	0.60	0.56	14.79
2013-2014	6.07	0.65	0.59	16.63
2014-2015	6.54	0.71	0.64	18.78
2015-2016	7.06	0.76	0.69	20.84
2016-2017*	7.62	0.82	0.74	23.14

*predicted values

3.2.2 City of Tshwane metropolitan municipality

The relevant policies within the City of Tshwane are the sanitation and water tariff policies which outline the approach taken by the municipality when setting water and sanitation charges. There are three different charge categories for industrial effluent.

1. **Normal conveyance and treatment charge**: Applies to effluent of the same quality as domestic wastewater discharged to sewer and is calculated by multiplying the combined unit conveyance and treatment cost by the volume discharged. Industrial consumers are charged the tariff cost with a rebate of 10%.

2. **Extraordinary treatment charge:** Applies when the pollution loading exceeds that of "normal" domestic wastewater and is calculated according to Equation 2:

$$Tc = Qc.t[0.6\,\frac{(CODc-CODd)}{CODd} + 0.25\,\frac{(Pc-Pd)}{Pd} + 0.15\,\frac{(Nc-Nd)}{Nd}] \qquad \text{Equation 2}$$

Where:

T_c = extraordinary cost to the consumer, Q_c = wastewater volume (kL), t = unit treatment cost of wastewater (94c/kL in 2014), COD_c = total measured COD (mg/L), COD_d = COD of domestic wastewater (710 mg/L), P_c = measured orthophosphate (mgP/L), P_d = orthophosphate concentration of domestic wastewater (10 mgP/L), N_c = measured ammonia concentration (mgN/L), N_d = ammonia concentration of domestic wastewater (25 mgN/L)

$$T_C = Q / D.N\,[C_{AIP} - B_{LL}/W_{PL}]t_{NC} \qquad \text{Equation 3}$$

Where:

T_c = charge for non-compliance, Q = monthly volume in kL, D = working days in the month, N = number of days exceeding by-law, C_{AIP} = ave. concentration of parameter exceeding by-law, B_{LL}= by-law limit, W_{PL}= Water Affairs standard limitation on parameter exceeding by-law, t_{NC} = tariff (65c/kL)

The cost of potable water provided by the City of Tshwane is calculated using a sliding scale determined by how much water is utilised. The more water consumed, the less the charge (Table 2). There is one basic charge (per kL) for effluent discharge (Table 2), calculated on 60% of incoming water.

Table 2: Basic unit costs for water and industrial effluent for the City of Tshwane

Period	Effluent	Water	Water	Water
	All volumes (R/kL)	**0-10 000 kL (R/kL)**	**10 001-100 000 kL (R/kL)**	**>100 000 kL (R/kL)**
2012-2013	4.66	11.89	11.29	10.52
2013-2014	5.13	13.08	12.42	11.57
2014-2015	5.64	14.39	13.66	12.73

3.2.3 City of Cape Town metropolitan municipality

The discharge of industrial effluent has been promulgated in the City of Cape Town industrial wastewater and effluent by-law of 2006, which was amended in 2014. The volume of industrial wastewater discharged is calculated by the municipality after deducting "fair" amounts for atmospheric losses, water used for irrigation, and water present in product. The charge for industrial wastewater discharge to sewer is calculated according to Equations 4 and 5. Limits are set for certain parameters (Table 3). If these are exceeded, surcharges apply in accordance with Equations 4 and 5.

$$Vw(SVC) + \frac{VieT(COD-1000)}{1500} + VieT(SF) \qquad \textbf{Equation 4}$$

Where:

Vw = Total volume of water discharged, SVC = Sewage volumetric charge, VieT = Total industrial effluent discharged, SF = surcharge factor calculated according to equation 4

$$SF = (X - L)/L \qquad \textbf{Equation 5}$$

Where: X = concentration of one or more parameters from schedule (Table 3), L = limit applicable to particular parameter (Table 3).

Table 3: Parameter limits for industrial wastewater for discharge to sewer (City of Cape Town)

General parameters		Chemicals (non-metals)		Metals	
Parameter	**Limit**	**Parameter**	**Limit**	**Parameter**	**Limit**
Temp	< 40°C	TS, Cl, SO_4^{-2}	1 500 mg/L	Fe	50 mg/L
EC (at 25°C)	500mS/m	Na	1 000 mg/L	Zn	30 mg/L
pH (at 25°C)	5.5 – 12	FOG + waxes	400 mg/L	Cr, Cu	20 mg/L
COD	5000 mg/L	PI, SO^{2-}	50 mg/L	Total	≤ 50 mg/L
Sett.S	50 ml/L	P	25 mg/L	A, B, Pb,	
SS	1000 mg/L	CN	20 mg/L	Se, Hg, Ti	5 mg/L each
TDS	4 000 mg/L			Cd, Ni	Total ≤ 20mg/L

EC = electrical conductivity, Sett.S = settleable solids, SS = suspended solids, TDS = total dissolved solids, TS = total sugars and starches as glucose, FOG = fats, oils, grease

The basic unit costs for the City of Cape Town are summarised in Table 4.

Table 4: Basic unit costs for water for industry and industrial effluent (City of Cape Town)

Period	**Effluent Standard R/kL**	**Effluent Oxidation dams (R/kL)**	**Water (R/kL)**
2014-2015	11.84	11.13	15.41
2015-2016	13.14	12.36	17.10

Calculated on 95% of water consumption. This figure may be adjusted by the director of water services.

3.2.4 Ekurhuleni metropolitan municipality

There are many industries in this metropole and the wastewater treatment facilities discharge to inland systems. The charges levied by Ekurhuleni municipality, in terms of their by-laws and tariff structure, are particularly complicated. There is a general stipulation that effluent cannot be discharged if it is above 44°C, if it contains tars, bitumen or asphalt, or if it contains substances that are explosive, flammable, poisonous, corrosive, give off offensive gases or vapours, create excessive foam, have an undesirable colour, impart a bad taste after chlorination, have a negative effect on the receiving wastewater treatment facility, or are hazardous to the staff at the facility. Industrial wastewater discharge costs are calculated according to Equation 6, and limits are imposed (Table 5). Limits are subject to a degree of flexibility on consultation with the council on an individual basis. It there is no accurate flow meter, the discharge volume is determined in consultation between the service provider and user “as accurately as is reasonably practical”. Basic unit costs are summarised in Table 6.

$$Ti = c/12\left(\frac{Qi}{Qt}\right)\left[a + b\left(\frac{CODi}{CODt}\right) + d\left(\frac{Pi}{Pt}\right) + c\left(\frac{Ni}{Nt}\right) + f\left(\frac{SSi}{SSt}\right)\right] \qquad \textbf{Equation 6}$$

Where:

Ti = monthly charge, C = full cost of effluent treatment for municipality, which is the sanitation cost + 15%, Qi = ave. flow from premises (FP) in kL/d, Qt = ave. daily inflow in kL to council treatment system over 5 years (CS5Y), CODi = ave. monthly COD, CPDt = ave. COD to CS5Y, Pi = ave. monthly σ-P conc., Pt = ave. σ-P conc CS5Y, Ni = ave. monthly NH_3/NH_4 conc., Nt = ave. NH_3/NH_4 conc. CS5Y, SSi = ave. SS conc., SSt = ave. SS conc. CS5Y, a = portion of fixed cost for wastewater treatment and conveyance, b,d,e,f = portion of cost directly related to the removal of COD (a), σ-P (b), NH_3/NH_4 (e), and SS (f)

COD, P and NH_3/NH_4 all measured in mg/L

Table 5: Fixed costs applicable to Equation 6

	Qt	CODt	Pt	Nt	SSt	A	B	d	E	f
2014/15	698605	757	4.4	23.1	294	0.29	0.26	0.16	0.15	0.14
2015/15	718370	753	3.81	22.7	296	0.29	0.26	0.16	0.15	0.14

Table 6: Basic unit costs for industrial effluent and water use by industries (Ekurhuleni municipality)

Period	**Effluent**	**Effluent**	**Effluent**	**Water**	**Water**	**Water**
KL	**0-5 000 (R/kL)**	**5 001-25 000 (R/kL)**	**> 25 000 (R/kL)**	**0-5 000 (R/kL)**	**5 001-25 000 (R/kL)**	**> 25 000 (R/kL)**
2014-2015	6.89	4.03	3.39	14.21	14.45	15.08
2015-2016	7.54	4.41	3.71	16.28	16.55	17.27

Above costs are exclusive of VAT

If limits (Table 7) are exceeded, the additional charge that is imposed, as of 2015/2016 financial year, is the highest of R1.66/kL or R1 649/month for each parameter exceeding the limit.

3.2.5 Breede Valley municipality

For the Breede Valley municipality, the by-laws relating to water supply, sanitation and industrial effluent (2008), apply for all industries within the boundaries of the municipality (Worcester, Rawsonville, De Doorns, and Touwsriver). Water usage charges for industries are determined by the tariffs outlined in Table 8. A separate set of tariffs come into play under water restriction conditions.

Table 7: Parameter limits for industrial wastewater for discharge to sewer (Ekurhuleni municipality)

Determinant		Determinant		Metals and other elements	
Parameter	**Limit**	**Parameter**	**Limit**	**Parameter**	**Limit**
pH	>10 < 6	Na	500 mg/L		
EC (@ 25℃)	500 mS/m	NH_4 (as N)	200 mg/L		
COD	5000 mg/L	σ-P (as P)	50 mg/L		
Phenols	150 mg/L	SO_4^{-2}	1800 mg/L		
Suspended non-organics	100 mg/L	SO^{2-} (as S)	10 mg/L	Ni, Zn, Co, Cr	20 mg/L each Total 40 mg/L*
FOGW > 10 000 kL/month	1 000 mg/L	H_2S	5 mg/L	Pb, Cu, Cd, As, B, Se, Hg, Mo	5 mg/L Total 20 mg/L*
FOGW >10000 kL/month	500 mg/L	CH_2O	50 mg/L	Al, Fe, Ag, W, Ti, Mn	20 mg/L*
FOGW in ether	500 mg/L	HCN	20 mg/L		
Anionic surface active agents	500 mg/L	Available Chlorine (Cl)	100 mg/L		
Caustic alk.	2 000 $CaCO_3$mg/L	Chloride (Cl)			
TS	1 500 mg/L				

EC = electrical conductivity, TS = total sugars and starches as glucose, FOGW = fats, oils, grease, waxes
*metal limits; if exceeded, in addition to fines, inspection charges ranging from R1346.00 (first inspection) to R8237 (third inspection) will be charged (2015/2016 rates)

Table 8: Basic unit costs for water use by industries within the Breede Valley municipality

Water use in kL (ranges)	**R (Ex VAT) 2014/2015**	**R (Ex VAT) 2015/2016**	***R (Ex VAT) 2014/2015**	***R (Ex VAT) 2015/2016**
0-20	7.32	7.76	7.32	7.76
21-40	7.92	8.40	7.92	12.60
41-60	8.70	9.22	8.70	13.83
61-100	9.75	10.34	10.07	15.51
101-150	10.15	10.76	10.49	16.14
151-300	8.76	9.29	9.08	13.94
301-600	7.53	7.98	7.79	11.97
601-1200	6.59	6.99	6.80	10.49
1201+	6.07	6.43	6.28	9.65

*Tariffs applicable under water restriction conditions

Industrial effluent discharged into the sewage disposal system needs to conform to certain norms and standards as outlined in the municipality's by-laws:

1. Effluent discharged should not be harmful to the health of anyone involved in the operation or maintenance of the sewage system;
2. The effluent should not be harmful to the sewage disposal system;
3. The effluent should not interfere with any of the processes used for the treatment of sewage, re-use of treated sewage, or require disposal of solids generated during the treatment process.

These norms and standards may vary depending on the communities, geographical areas and types of premises, but all industries are required to adhere to these norms and standards.

The costs for the treatment of industrial effluent are typically calculated according to Schedule C specified by the Model By-Laws Pack (DWAF, 2005) as outlined by Equation 2 (Section 3.2.2).

3.2.6 Amathole District municipality

Interestingly, the Amathole District municipality has a flat rate per kL for industrial and agricultural water use, no matter whether it is in a low range (0-6) or high (>501). The charge rate has increased over the past three years from R22.19 (2013/2014) to R23.52 for 2014/2015 to R24.93 for 2015/2016. It is also one of the few municipalities that specifies in its by-laws that a water audit may be requested within one month after the end of the financial year. The audit requires the inclusion of information related to water use, effect of seasonal variation in water demand, water pollution monitoring methods, initiatives to monitor water usage, etc. Discharge of industrial effluent to the sewage system needs to comply to a range of standards and criteria:

1. The concentration of any substances in the effluent may not result in any effect on the sewage treatment plant or other discharge areas in terms of taste, colour, odour, temperature or foam;
2. The effluent may not affect the potential re-use of treated sewage;
3. The effluent may not affect any processes used for the treatment of sewage for re-use or for the production of sludge for disposal;
4. The effluent may not contain any compounds that would be resistant to standard sewage treatment processes;
5. The effluent may not contain anything that may result in the disruption or breakdown of the processes that take place during sewage treatment;
6. The effluent may not adversely affect the health and safety of any person;
7. The effluent may not cause damage to the structural integrity of the disposal system;
8. The effluent may not impact any property used by the municipality;
9. The effluent may not cause the restriction of flow of the sewage through the disposal system.

Strict regulations are laid out in the municipality's by-laws with regards to the quality of industrial effluent discharged. Owners are required to monitor the effluent quality and are required to conduct prescribed tests. These tests may also be conducted by the municipality and if any discrepancies are detected, the values determined by the municipality will apply. Parameters that are monitored are the strength of the effluent (COD, suspended solids, ammonia, ortho-phosphate), the concentration of Group 1 and 2 metals, the pH, and the conductivity. Charges related to the quality of the effluent are based on the formula for industrial effluent as set out in Schedule C of the Model By-Laws Pack (DWAF, 2005) (see Equation 2, Section 3.2.2).

3.2.7 Nelson Mandela Bay metropolitan municipality

For the Nelson Mandela Bay metropolitan municipality, different tariffs apply depending on whether the industry is based within the boundary of the municipality or outside the municipality, and whether water restrictions are in place (Table 9).

Table 9: Basic unit costs for water use by industries within the Nelson Mandela Bay metropolitan municipality

	R (Ex VAT)/kL 2015/2016
Treated water for industrial premises	10.67
Treated water for industrial premises – water restrictions	13.90
Raw water for industrial premises	8.57
Raw water for industrial premises – water restrictions	8.57
Treated water for industrial premises outside municipality boundary	13.36
Raw water for industrial premises outside municipality boundary	10.67
Raw water for industrial premises outside municipality boundary – water restrictions	13.90

Tariffs for the supply of treated water to industrial premises outside the municipality boundary is set at R17.26/kL, but may vary depending on the water usage:

- Up to 0.8 kL/day = R13.36
- Next 0.8 kL/day = R29.73
- Next 1 kL/day = R45.05
- Additional consumption = R90.09/kL

As per the other metropolitan municipalities included in this section, Nelson Mandela Bay metropolitan municipality has strict regulations pertaining to what may be discharged to the sewage system. This is clearly outlined in “Chapter 4: Protection of the sewerage system” of the municipality’s by-laws. Notably, mention is made that the discharge should not contain any substances that can cause offensive gases, should not contain dye or dye residue, or any non-biodegradable substance. These have a specific link with the textile industry and will be the focus in the sections on best practice. The specific parameters that are monitored for industrial wastewater discharged to the sewer are summarised in Table 10.

Table 10: Parameter limits for industrial wastewater for discharge to sewer (Nelson Mandela Bay metropolitan municipality)

Parameter	Limit
Temperature	< 44°C
Electrical conductivity	< 500 mS/m at 25°C
pH	6.0-12.0
Permanganate	≤ 1 000 mg/L
COD	< 10 000 mg/L
Sulphides (S)	5 mg/L
Cyanides (HCN)	10 mg/L
Sulphates (SO_4)	1 500 mg/L
Fluorides or fluorine (F)	5 mg/L
Suspended solids	1 000 mg/L
Tar products and distillates	50 mg/L
Chlorides (Cl)	1 000 mg/L
Group 1 metals	
Chromium (CrO_3)	20 mg/L
Copper (Cu)	20 mg/L
Nickel (Ni)	20 mg/L
Zinc (Zn)	20 mg/L
Total collective concentration of Group 1 metals	50 mg/L
Group 2 metals	
Arsenic (As)	5 mg/L
Boron (B)	5 mg/L
Cadmium (Cd)	5 mg/L
Cobalt (Co)	5 mg/L
Lead (Pb)	5 mg/L
Molybdenum (Mo)	5 mg/L
Selenium (Se)	5 mg/L
Mercury (Hg)	5 mg/L
Total collective concentration of Group 2 metals	15 mg/L

Section 4: Water use and waste management

4.1 Water and the textile industry

As indicated in Section 1, the textile industry can broadly be grouped into those involved in dry processing (yarn manufacturing, weaving, and knitting) and those involved in wet processing (preparation, dyeing, and finishing). The textile industry is very water intensive butwater usage varies widely depending on the type of material being processed (raw material, yarns, wool, etc.), the processes, and the finishing requirements (Chougule and Sonaje, 2012). For the purpose of this survey, textile companies were grouped into three clusters:

1. Dyers and finishers
2. Producers (raw material processors and woven textiles)
3. Technical and traditional textiles

These groupings exclude companies involved in trimming, production of threads, yarns, fibres, shoulder pads, home textiles, interlinings, and knitted fabrics (dry processing).

4.2 Water use

In a Water Research Commission-funded study by Cloete et al. (2010), the textile industry was identified as one of many industries that are among the top 80% of water users in South Africa. Of all the industries analysed in this study, the textile industry was the highest user of water in the eThekwini metropolitan municipality area (36% of total water use), second highest user in the City of Cape Town metropolitan municipality (29% of total water use), and third highest user in the Amathole District municipality (12% of total water use) (Cloete et al., 2010).

In order to determine current water use in the textile industry, various companies were approached and asked to provide information pertaining to the following (Annexure 2):

- Source of the water used in the production processes
- Water quality requirements and pre-treatments carried out
- Water use per unit of production

The information obtained from this survey was compared to international benchmarks set out for the textile industry.

4.2.1 Source of water and pre-treatment requirements

Textile industries often make use of different sources of water, e.g. rivers, borehole water, municipal water, and reclaimed waste streams (Chougule and Sonaje, 2012). Table 11 summarises information obtained from participating companies with regards to their sources of water and the pre-treatments required prior to use.

Table 11: Summary of water sources and treatment processes used in the textile industry

Company reference number (Province)	Water source	Water treatment	Comments
Dyers and finishers			
1 (KwaZulu Natal)	Municipal water River water	None Filtration and softening	Production is seasonal Company tests river water for colour, hardness, pH and solids content; pH needs to be 7-9.
2 (KwaZulu Natal)	Municipal water	None	Production is seasonal
3 (Gauteng)	Municipal water	None	None
4 (Gauteng)	Municipal water	None	None
5 (Eastern Cape)	Municipal water	None	Production is dependent on client demand
6 (Western Cape)	Municipal water	None	Production is seasonal (peak periods correspond with fashion seasons: October/November and May/June)
7 (Western Cape)	Municipal water	None	None
8 (KwaZulu Natal)	Municipal water	None	Production is seasonal (peak period: May-November)
9 (KwaZulu Natal)	Water purchased from external company; if not available, municipal water is used	None	Production is seasonal – Summer production (August to December) is normally higher than winter
Producers			
1 (Western Cape)	Municipal water	None	None
2 (Western Cape)	Municipal water	None	None
3 (Eastern Cape)	Municipal water	None	None
4 (Eastern Cape)	Municipal water	None	Production is seasonal
5 (KwaZulu Natal)	Municipal water	None	None
Technical and traditional textiles			
1 (KwaZulu Natal)	Municipal water	None	Production is seasonal
2 (Eastern Cape)	Municipal water Dam water (on-site)	None	None
3 (Gauteng)	Municipal water	None	Production is seasonal (Winter time highest demand)
4 (Western Cape)	Municipal water	None	Production is seasonal (peak period: September/October to December)
5 (Western Cape)	Municipal water	None	Production is seasonal (peak period: October to February)
6 (Western Cape)	Municipal water	None	None
7 (Eastern Cape)	Municipal water	Water is filtered through a demineraliser	None

Of the 21 companies surveyed, only one supplemented municipal water with river water, one supplemented with dam water, and another purchased water from a local chemical manufacturing company. The river water required a pre-treatment process (filtration and softening) to ensure a good enough quality water supply for the dyeing process, and is typically tested for colour, hardness, pH and solids content. There was no indication as to whether the dam water required pre-treatment or what it was used for. None of the companies indicated whether they monitored the quality of the intake supply of municipal water and therefore no indication was given regarding the pre-treatment of the municipal water supply prior to application in the production processes. Steffen Robertson and Kirsten Consulting Engineers (WRC, 1993) did not provide any indication as to the water sources used by the textile industries surveyed previously and it is therefore unclear whether there has been a change in the water sources used by the industry.

4.2.2 Water consumption and specific water intake

In the textile industry, water is not only used for specific processes (which include, but are not limited to, sizing, desizing, scouring, mercerising, bleaching, dyeing, printing, and finishing processes), but is also used for cleaning and cooling processes, and serves as the delivering agent for any chemicals used for the treatment of the textiles. The amount of water used during these processes is dependent on a wide range of factors, some of which were previously identified by Steffen Robertson and Kirsten Consulting Engineers (WRC, 1993):

- The type of fibres being processed by the company (blended or unblended; proportions of blends)
- The fibre form (woven fabric, knitted fabric, stock, yarn, etc.)
- Any treatment and/or pre-treatment requirements
- The type of dye and dyeing process being used
- The type and age of the equipment
- Any ancillary processes required, e.g. utility cooling, air-conditioning, frequency of cleaning.

It is essential that the different textile companies monitor the water consumption of the different processes to evaluate water intake and consumption. Only one of the four companies surveyed was able to provide a breakdown of the water consumption that takes place for specific processes, while the others indicated that they only monitor total intake and use. The annual water consumption and specific water intake (SWI; expressed in litres of water per kg or per m of product) for the companies surveyed are provided in Table 12.

Table 12: Summary of the annual water consumption and specific water intake (SWI) for the textile industry

Company reference number	Main materials	Production processes	Annual water use (kL)	Annual production (kg, m or units)	SWI
Dyers and finishers					
1	Natural cotton, cotton knits, poly-cotton, nylon, synthetic fabrics	Dyeing, finishing, printing	274 333 in 2014 (approximately 140 kL/day)	5 486 660 kg (inferred from SWI provided)	50 L/kg (average provided by company)
2	Cotton garments	Dyeing	Not indicated	Not indicated	15 L/kg (average provided by company)
3	All types, especially nylon, cotton	Printing	Not indicated	Not indicated	25 L/m
4	All types	Pre-treatment, dyeing, finishing	Not indicated	Not indicated	76 L/kg
5	Dyed and interweaving, knitted fabrics; cotton piece-dyed fabrics; garments; yarn dyed fabrics; printed fabrics (polyester, cotton)	Preparation, dyeing, printing, finishing	Not indicated	Not indicated	Not indicated
6	Dyed cotton and nylon fabrics (cotton, nylon, sometimes polyester)	Dyeing	Not indicated	Not indicated	113 L/kg
7	Bleached, dyed, printed, and finished products (cotton and poly-cotton greige fabric)	Dyeing, bleaching, printing	338 984.8 (inferred from production and SWI provided)	4 402 399.9 m (2015)	77 L/m
8	Various textiles	Dyeing	13 475 (inferred from production and SWI provided)	245 000 kg (capacity; not actual)	55 L/kg
9	Not specified	Dyeing and printing	204 334 (inferred from SWI provided for dyed fabric) 22 211 (inferred from SWI provided for printed fabric)	3 523 000 kg (dyed fabric) 3 173 000 m (printed fabric)	58 l/kg and 7 L/m
Producers					
1	Woven fabric, knitwear, yarn (fibres and yarn made from cotton,	Dyeing, spinning, weaving, finishing, knitting	99 000 total Finishing: 34 650 Dyeing: 32 670 Spinning: 24 750 Other: 6 930	3 972 732 m	40 L/m

Company reference number	Main materials	Production processes	Annual water use (kL)	Annual production (kg, m or units)	SWI
	wool, polyester, viscose)				
2	Sewing threads (polyester, nylon, acrylic)	Batch dyeing	28.51	240 962 kg	83 L/kg (provided by company; was 120 L/kg in 2014)
3	Heavy and light webbings (woven fabric)	Weaving and finishing	Not indicated	Not indicated	Not indicated
4	Polyester fabric	Preparation, dyeing and finishing	60 000 (average of 5 ML/month)	Not indicated; seasonal (approx. 6000 m/day)	34.7 L/m (calculated on monthly average information)
5	Cotton yarn (cotton lint)	Spinning	Not indicated	Not indicated	6.42 L/kg
Technical and traditional textiles					
1	Yarn, nylon, polyester, aramid	Industrial textiles: warp and weaving Clothing: warp, weaving, scouring, dyeing, heat setting Technical textiles: scouring, dyeing, drying, coating	Not indicated	Not indicated	60 L/kg (average provided by company and equated to 18 L/m)
2	Traditional clothes, sheeting, apparel	Sizing, preparation, dyeing, printing, finishing	600 000 (2 000 kL/day; operational 25 days/month)	18 000 00 m	33.33 L/m
3	Blankets and throws (wool, nylon, polyester)	Blending, carding, spinning, cone wending, waving, finishing and make up	31.2 (average of 2.6 kL/month)	432 000 units (blanket)	0.072 L/unit
4	Knitted and woven products for the mattress manufacturing industry (polyester and polypropylene)	Weaving and circular knitting; finishing (laminating); extrude polypropylene yarn	2 556 (average of 213 kL/month)	6 960 000 m (average of 580 km/month)	0.367 L/m
5	Tufted bathroom mats and sets, cotton blankets, throws, duvets,	Carding, quilting, fibre opening, dyeing	Not indicated	Not indicated	69.47 L/kg

Company reference number	Main materials	Production processes	Annual water use (kL)	Annual production (kg, m or units)	SWI
	pillows, stitchbond fabrics (material shopping bags); cotton, polyester, acrylic, various other				
6	Woven/knitted products (upholstery, curtaining, protective wear – ballistics); cotton, nylon, kevlar	Weaving, knitting, finishing (colouring, functional finishes)	Not indicated	Not indicated	0.192 L/m
7	Industrial textiles used in manufacture of conveyor belts (polyester, nylon, cotton)	Twisting, weaving, and finishing (dipping in a latex solution)	0.360	2 400 00 kg	0.00015 L/kg

It is clear from the results presented in Table 12 that the conclusions and recommendations made by Steffen Robertson and Kirsten Consulting Engineers (WRC, 1993) are still valid:

> ***Note:*** *SWI will vary dramatically depending on the type of processes and materials used by the different companies and as such, individual textile companies should aim to establish their own targets for the improvement of SWI rather than trying to conform to a national average SWI*

In 1993, the national average SWI was calculated to be 137 L/kg. The SWI values of 15 companies were reported in the 1993 national survey, and ranged from 95 L/kg to 459 L/kg. The SWI values reported here are well below the national average reported in 1993, indicating that water-saving measures implemented in the industry since 1993 have been highly successful.

4.3 International trends

Environmental, Health, and Safety Guidelines for the textile manufacturing industry were published in 2007 by the International Finance Corporation (IFC; World Bank Group). The EHS guidelines aim to provide benchmarks for resource consumption, wastewater quality, and air emissions. These benchmark values are based on data collected in a survey funded by the European Commission. For water consumption, benchmark values are provided for specific processes (Table 13). It is difficult to determine whether SA textile companies comply with the SWI recommendations mainly because the SWI for the separate production processes is not necessarily monitored/determined.

Table 13: Recommended specific water intake targets for the textile industry (IFC, 2007)

Process	SWI (L/kg)
Wool scouring	2-6
Yarn finishing	70-120
Yarn dyeing	15-30 (dyeing) 30-50 (rinsing)
Loose fibre dyeing	4-15 (dyeing); 4-20 (rinsing)
Knitted fabric finishing	70-120
Woven fabric finishing	50-100
Dyed woven fabric finishing	< 200

4.4 Water use: Best practices

Water consumption by the textile industry in South Africa was estimated to constitute 1.55% of total water use by the industrial sector (Cloete et al., 2010). Water is a scarce commodity in South Africa, where the average annual rainfall amounts to less than 60% of the world average. It is thus an imperative to encourage industrial sectors to minimise the consumption of water, and to re-use and recycle water and effluent where possible (Gravelet-Blondin et al., 1997).

Water use may be reduced by allocating water consumption to various water users on-site. This can be achieved by the use of machine meters, flow-monitoring devices, direct observations (e.g. a water pipe involved during the process of producing textiles can be disconnected and timed to determine how long it will take to fill a known volume), equipment specifications, estimates, and calculations. Information about allocated water consumption could provide an area of focus for potential improvement.

A Good Practice Guide for water and chemical use in the textile dyeing and finishing industry was published in 1997 by the Environmental Technology Best Practice Programme, in collaboration with Entec UK Ltd. According to the guide, a 20-50 % reduction in water usage was achieved by textile companies in the UK and abroad by applying water consumption awareness and action. Some simple options for reducing the use of water are further outlined below and summarised in Figure 17.

Figure 17: Recommended best practices to limit water consumption in the textile industry (Barclay and Buckley, 2002; Entec UK Ltd. (1997)

Repair of faulty valves, leaks, installation of meters:

Establish maintenance checklists to avoid constant repair of faulty parts and equipment. In the event of a fault, put in place priorities for repair depending on the severity of the fault. Substantial water losses during production processes may occur even if a leak seems insignificant – small, constant leaks continuing for 24 hours a day, seven days a week, cause considerable loss of water, especially if multiplied over the area of an entire site. The installation of water meters at the different process steps will allow the company to monitor water use; any variations in water use could be an indicator for faulty valves or the presence of leaks.

Turn off water:

Turn off running taps and hoses to achieve substantial savings. Alternatively, install self-shutting, trigger-controlled nozzles on hoses to automatically switch off the water flow. Both water and energy can be conserved by avoiding the circulation of cooling water when machines are non-operational. Operators may switch off machines during breaks and/or low production periods, as well as at the end of each day.

Reduction in the number of process steps:

Regularly review the necessity of every stage in the textile producing process in light of the continuous advancement of chemical performance (e.g. rinse water for lighter shades of textiles could be reduced by cutting down the number of wash cycles from the bleaching process – this in turn will reduce effluent costs).

Optimise process water use:

Optimise water consumption in continuous and batch operations through various adjustments to a process. Table 14 summarises some of the water reduction procedures that can be implemented during washing and rinsing (The Textile Industry and the Environment, 1993; Entec UK Ltd., 1997).

Table 14: Reduced water usage during washing and rinsing– a water use best practice approach

Dyeing operation	Water reduction procedure
Jig dyeing	A 15-79% reduction in water consumption was made possible by stepwise rinsing instead of overflow rinsing Automatic water stops may be introduced during this process to gain a 20-30% saving
Continuous dyeing	Counter-current systems are an effective washing method which saves on the consumption of fresh water – this system is also beneficial as it promotes yield equalisation and neutralisation effects during effluent blending
Winch dyeing	A 25% reduction in water consumption was realised by avoiding overflowing after dropping the dye batch
High and low dyeing	Approximately 50% of water consumption was reduced after switching from overflow rinsing to pressure-jet dyeing batch-wise rinsing
Beam dyeing	Approximately 60% of water usage can be reduced by preventing overflow during rinsing and soaking

Re-use process water and recycling cooling water:

Process water can be re-used in other textile operations, especially where the quality of the water is not a factor, e.g. dilute washwater generated during one process can be used as the first wash/rinse step of another process, or can be recycled to be used in cooling processes.

During textile production, water and steam in heat transfer systems often gets lost via evaporation, drainage or condensation. The use of re-circulating systems could contribute to water savings of up to 90%. These systems incorporate chillers or cooling towers for cooling, and boilers for heating – the process takes place in a heat exchanger which allows for the re-circulation of water in a closed system. Gradual enrichment of impurities occurs in these systems causing scale formation, corrosion, biological growth and deposition on heat transfer surfaces. As a means to reduce these impurities, a certain fraction of water is removed from the system (blown-down) and replaced with fresh water (make-up). Chemicals which are designed to lower corrosion, biological growth and scale formation can be added to the water circulating in the system to improve heat transfer and in turn reduce water consumption by reducing the need for blow-down (United States Environmental Protection Agency, 1996).

> In a Clean by Design initiative launched in China in 2014, various textile companies managed to decrease their water consumption by up to 36.1% through the implementation of process water re-use, and up to 26.6% through the re-use of cooling water (Greer et al., 2015).

Upgrade equipment:

More efficient and effective technologies may replace existing ones, e.g. high-pressure, low-volume cleaning equipment; in-place cleaning systems; and using lower liquor ratios when operating textile dyeing machinery. The initial investment is quite costly, but the benefits will not only be reflected in decreased water consumption, but also in decreased energy requirements and a decrease in effluent generation (Greer et al., 2015).

4.5 Status of water use best practices in the South African textile industry

The companies interviewed were asked to indicate any water management practices that have been implemented to avoid water intake wastage. Using Figure 17 as a guide, the various measures currently being implemented by the participating companies are highlighted in Figure 18.

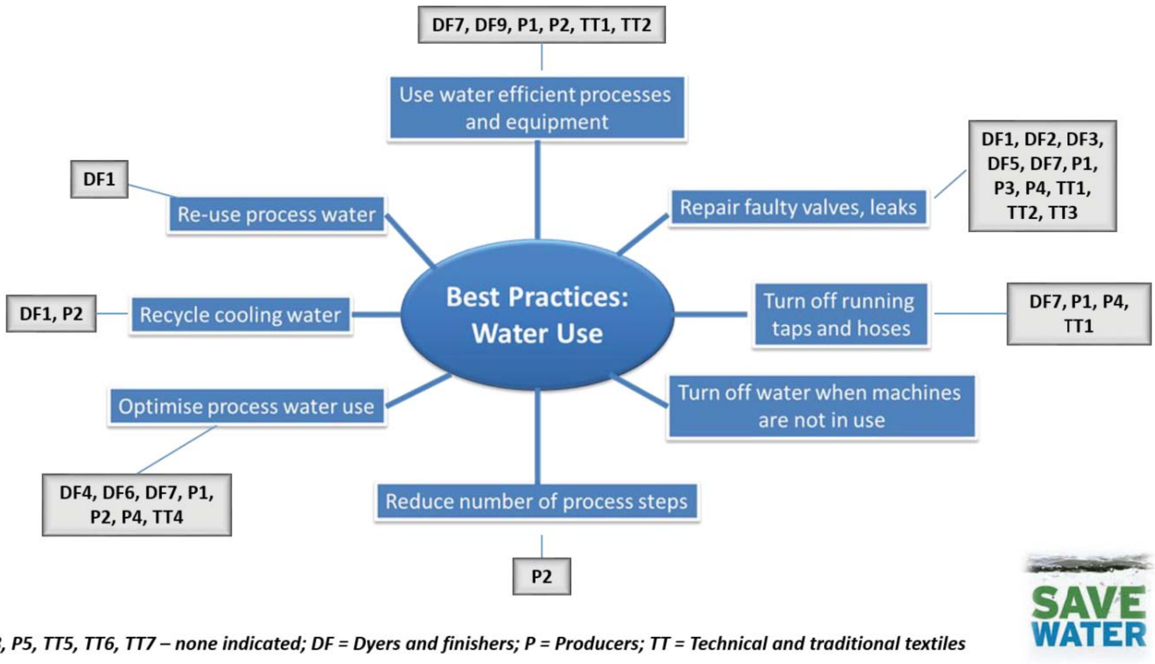


Figure 18: Water use best practices employed by the 21 textile companies who participated in the national survey

Company DF1 is an example of how implementing best practices can influence SWI readings. DF1 used to have an SWI of 90 L/kg, but since the company embarked on a water- and energy-saving programme, water use in the production process has decreased to 50 L/kg of fabric. The production process specifically uses about 140 kL of water per day of which 75 kL is recycled. Water from the bleaching process is pumped into a tank and used in the printing department to clean screens and wash machines. It should be noted that water consumption and subsequently wastewater generation vary according to the volume of production. The target is to use about 30 to 40 litres per kg of fabric, but they are still trying to find a way of meeting this target as this will depend on the types of fabrics processed. In addition, water use is monitored daily through reading the intake every morning and comparing daily readings in order to determine trends (change in consumption per volume of processed fabrics). Taps and other water sources such as pipes, tapping points and connections to machinery are monitored daily and repaired when necessary.

Section 5: Wastewater generation and management

In order to determine the current status of wastewater generation and management in the textile industry, various companies were approached and asked to provide the following information (see questionnaire, Annexure 2):

- The volume of wastewater generated
- Whether pre-treatment of effluent is carried out prior to discharge
- Whether effluent pollutant loads such as chemical oxygen demand (COD), total dissolved solids (TDS) and settleable solids (SS) are monitored

5.1 Effluent generation and pollutant loads

The high volumes of water used in the textile industry almost directly correspond to the volume of wastewater generated. Specific effluent volumes are typically 80-90% of the SWI value, depending on the production processes employed by a specific company (WRC, 1993). Each of the different wet processes in textile manufacturing contributes towards the pollutant load of the textile effluent and typically contains suspended solids, mineral oils (surfactants, lubricants, grease, etc.), organic compounds (e.g. dyes), and bleach. Some dye effluent may also contain metals such as chromium, copper, zinc, lead, or nickel. In addition, companies that are involved in the processing of raw materials, such as wool or cotton, will also generate wastewater containing pesticides, microorganisms, and other contaminants (IFC, 2007).

The wastewater generated during the different wet processing steps (IFC, 2007; Barclay and Buckley, 2002) contributes variable quantities of the pollutants mentioned above:

- **Scouring**: heated water and an alkali or detergents are required during this process for the removal of grease, vegetable impurities or other contaminants from raw materials. This results in alkaline wastewater that contains suspended solids, natural oils, and surfactants, resulting in high COD loads.

- **Sizing**: polymers such as starches, waxes, carboxymethyl cellulose and polyvinyl alcohol are present in effluent generated during this process, resulting in high COD loads.

- **Desizing**: this process may contribute up to 50% of the total COD load due to the high content of organic matter and solids removed from raw material.

- **Bleaching**: various bleaching agents are used by the textile industry, each of which will contribute towards the pollutant load of any effluent generated during this process, e.g. chlorine-based bleaches results in the release of organic halogens such as trichloromethane.

- **Mercerising:** wastewater generated during this step is highly alkaline due to the use of caustic soda.

- **Dyeing:** the dyeing process results in a wastewater that contains various pollutants (e.g. halogens, metals, amines, salts, reducing/oxidising agents, antifoaming agents, and may contain colour pigments.

- **Printing:** this process may result in wastewater with a high volatile organic compound level and an oily appearance due to the dyes, pigments, resins and organic solvents used.

- **Finishing:** effluent generated from this process is slightly alkaline with a low BOD, but contains inorganic salts and toxic compounds.

Effluent generation by the participating companies is summarised in Table 15. The high levels of effluent produced (on average >70% of water intake) confirm the conclusions made in the previous national survey (WRC, 1993). The high effluent levels for company DF1, is mainly due to the fact that steam generated elsewhere is used by the company, thereby contributing towards the increased effluent levels compared to the water intake levels.

Table 15: Effluent generation in the textile industry

Company reference number	Annual water use (kL)	Volume effluent generated (kL/year)	Effluent as a % of water intake
Dyers and finishers			
1	274 333 in 2014	284 075 (51 L/kg product)	103%*
2	Not indicated	Not determined	96.8%**
3	Not indicated	Not indicated	20% (estimated by company)
4	Not indicated	Not indicated	90% (estimated by company)
5	Not indicated	Not monitored	Unknown
6	Not indicated	Not indicated	100% (estimated by company)
7	338 984.8	216 950	68%
8	13 475	12 127.5	90% (estimated by company)
9	226 545	219 758.65	97% (estimated by company)

Producers			
1	99 000	75 500	76.26%
2	28.51	28.51	100%
3	Not indicated	Not monitored	Unknown
4	60 000	Not monitored	Unknown
5	Not Indicated	Not monitored	Unknown
Technical and traditional textiles			
1	Not indicated	106 800***	Unknown
2	600 000	540 000-840 000	90-140%*
3	31.2	Not indicated	25% (estimated by company)
4	2 556	Not monitored	Unknown
5	Not indicated	83 kL/day (seasonal)	Unknown
6	Not indicated	1 kL for rinsing and scouring; 20-30 L for ballistics – no annual statistic available	Unknown
7	0.360	Not indicated	Unknown

*additional sources of water result in higher effluent level than water intake; **estimation by municipality; ***based on an approximate effluent level of 8 900 kL/month

Very few companies could provide information on the pollutant load of the wastewater generated. Many are reliant on the local municipality to monitor key parameters (COD, electrical conductivity, pH, total dissolved solids) and reports are only provided if the readings are not within the acceptable levels for the municipality within which the company is located. Three companies provided limited information: for company P1, COD levels are well within the municipal requirement of 120 mg/L, with readings varying from 55 mg/L (lowest) to 85 mg/L (highest) over a 12-month period. Company P2 indicated measurement of pH (average of 8.5), temperature (average of 22.5°C) and total dissolved solids (average of 950) with averages well within limits of the municipality within which the company is located. Finally, company DF7 indicated that their average COD level for a 6-month period was determined to be 1 676 mg/L. Data obtained from company DF9 and from one of the local regulators are summarised in Table 16 along with the parameters recorded in the 1993 survey.

Table 16: Pollutant loads (ranges) for four South African textile companies

Parameter	Unit range	Average	Unit range recorded in 1993 survey	Average from 1993 survey (seven companies)
COD (mg/L)	291.00-1831.00	900.84	81-2686	1019
$NH3^+$ (mg/L)	0.03-31.45	3.71	-	-

Parameter	Unit range	Average	Unit range recorded in 1993 survey	Average from 1993 survey (seven companies)
$PO4^{-}$ (mg/L)	1.71-31.29	9.16	-	-
pH	6.62-10.10	8.38	6.5-11.15	8.85
Conductivity (mS/m)	78.52-1159.45	337.56	-	-
Total suspended solids (mg/L)	53.00-746.00	236.48	-	-
Total solids (mg/L)	753.33-7256.00	2491.80	-	-
Nitrate/Nitrite	0.45-4.09	1.23	-	-
Chlorides	66.36-3140.45	727.54	-	-
Sulphates	64.24-308.63	172.08	181-989	368.86

It is difficult to draw a direct comparison between the values recorded in the 1993 survey and the data collected in the current survey. As in the case of the SWI, the units recorded for the different parameters will vary according to the type of textile manufacturing taking place, e.g. pH values in the manufacturing of technical textiles may differ greatly from the pH values in textile dyeing. As recommended before, each company should set targets that should be guided by the regulations of the local authorities.

5.2 Effluent management

Wastewater generated in the textile industry is highly variable and dependent on the type of material produced and the processes and chemicals involved in the production of the specific type of textile (De Jager, 2013). Various treatment methods, typically classified as preliminary, primary, secondary, and tertiary are required to remove the pollutants from the textile wastewater. The treatment methods typically employed are summarised in Figure 19.

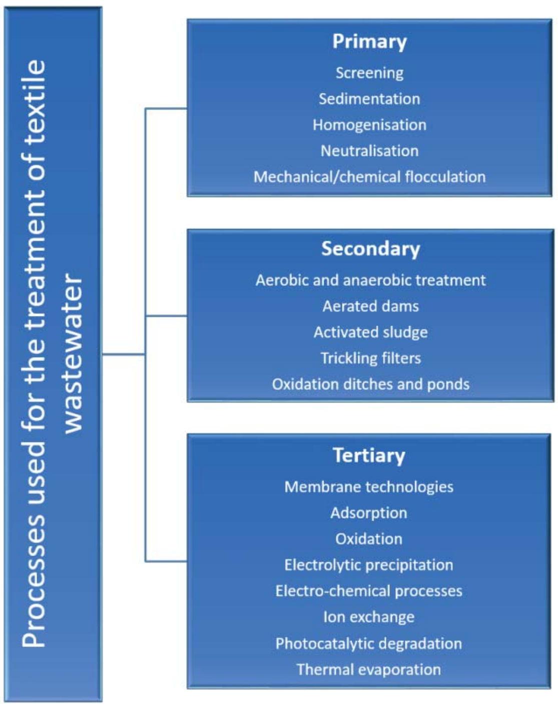


Figure 19: Summary of the primary, secondary, and tertiary treatment methods employed for the treatment of wastewater generated in the textile industry (adapted from Srebrenkoska et al., 2014)

Limited information on effluent management was obtained from the participating companies (Table 17). Effluent is typically not recycled due to the need for good quality water, but company DF1 re-uses water from the bleaching process, which is pumped into a tank and used in the printing department to clean the screens and wash the machines. A similar approach is taken by companies DF3 and DF9. Only five companies indicated that their wastewater is treated on-site prior to discharge, while two companies indicated that effluent is treated either off-site by a contractor or treated at a central facility prior to discharge to municipal wastewater treatment plants. Companies who do not pre-treat their effluent indicated that they do not have the necessary resources and infrastructure available to treat their wastewater prior to discharge.

Table 17: Effluent management practices in the textile industry

Company reference number	Effluent treatment	Tests carried out on-site	Other comments
Dyers and finishers			
1	Yes, but not on-site; mixed with other sources and treated by external service provider	None	Water from bleaching process is recycled
2	None	pH and settleable solids (not regularly)	No recycling of effluent
3	None	None	Sometimes effluent is used for the cleaning of painting panels
4	None	pH	No recycling of effluent
5	None	None (monitored by consultant)	No recycling of effluent
6	None	None*	No recycling of effluent
7	None	None*	No recycling of effluent
8	None	pH and settleable solids	No recycling of effluent
9	Yes, but not on-site; make use of a central treatment facility located within the industrial estate	Not defined, but tests performed by an outside company	Bleaching and rinsing water from fabric dyeing is re-used in printing department
Producers			
1	None	COD	Municipality monitors effluent quality monthly

Company reference number	Effluent treatment	Tests carried out on-site	Other comments
2	None	pH, temperature, TDS	No recycling of effluent
3	No, but allow settling before discharge	pH, EC, COD, TDS	No recycling of effluent
4	None	pH, TSS, EC	No recycling of effluent
5	None	None	None
Technical and traditional textiles			
1	Yes, on-site; flocculation using lime and ferric chloride	pH, colour and COD	No recycling of effluent
2	Pilot phase: filtration and reverse osmosis	None*	No recycling of effluent
3	Yes, use of a settling dam	None*	No recycling of effluent
4	Yes, use of a three-pit system to allow solids to settle out	None*	No recycling of effluent
5	None	None*	Plans in place to re-use effluent water that contains low salt and pH
6	None	None*	No recycling of effluent
7	None	None	None

*Dependent on municipality to monitor parameters

5.3 International trends

The potentially high impact of textile effluent on the environment and wastewater treatment plants necessitated the need to establish guidelines that are indicative of "good international industry practice" (IFC, 2007). Companies should be able to meet the requirements through the implementation of various best practices (as discussed later in this document). As in South Africa, the allowed levels of pollutants in textile effluent may vary from country to country or region to region, but generally should fall within the guideline values presented in Table 18. It is recommended that if more stringent measures are required, the more stringent values should be used as the benchmark value. Industry benchmark levels for wastewater generation for the different wet processes have also been established (summarised in Table 19).

Table 18: Guidelines for pollutant levels in textile effluent (IFC, 2007)

Pollutant/Parameter	Units	Guideline value
pH	-	6-9
BOD	mg/L	30
COD	mg/L	160
AO_X	mg/L	1
Total suspended solids	mg/L	50
Oil and grease	mg/L	10
Pesticides	mg/L	0.05-0.10
Cadmium	mg/L	0.02
Chromium (total)	mg/L	0.5
Chromium (hexavalent)	mg/L	0.1
Cobalt	mg/L	0.5
Copper	mg/L	0.5
Nickel	mg/L	0.5
Zinc	mg/L	2
Phenol	mg/L	0.5
Sulphide	mg/L	1
Total phosphorous	mg/L	2
Ammonia	mg/L	10
Total nitrogen	mg/L	10
Colour	m^{-1}	7 (436 nm, yellow) 5 (525 nm, red) 3 (620 nm, blue)
Toxicity to fish eggs	T.U. 96h	2
Temperature increase	°C	< 3
Coliform bacteria	MPN/100mL	400

AOx: adsorbable organic halogens; MPN: Most probable number of viable cells

Table 19: Industry benchmark values for the generation of wastewater in the textile industry (IFC, 2007)

Process	Industry benchmark (L/kg)
Wool scouring	2-6
Yarn finishing (wool)	35-45
Yarn finishing (cotton)	100-120
Yarn finishing (synthetic fibres)	65-85
Knitted fabric finishing (wool)	60-70
Knitted fabric finishing (cotton)	60-135
Knitted fabric finishing (synthetic fibres)	35-80
Woven fabric finishing (wool)	70-140
Woven fabric finishing (cotton)	50-70
Woven fabric finishing and printing (cotton)	150-80
Woven fabric finishing (synthetic fibres)	100-180

Note: In addition, sludge generated from the treatment of textile effluent, should not exceed 5 kg/m^3 of treated wastewater.

The need for standardising these industry benchmarks was recently highlighted in a literature review entitled "Textile industry wastewater discharge quality standards: literature review"

(ZDHC, 2015). This review emphasised that there is a need to limit the amount of hazardous chemicals discharged in wastewater generated in the textile industry and that standardised guidelines that apply across nations and brands should be formulated and implemented. The SA textile industry may need to explore the development of standardised guidelines that would apply in the SA textile industry or consider working with the various brands to standardise the guidelines at an international level.

5.4 Wastewater management: Best practices

The United Nations Environment Programme (UNEP) introduced the concept of "cleaner production" in 1989 (www.unepie.org/pc/cp/understanding_cp/home.htm). The South African National Cleaner Production Centre was established in 2003 within the CSIR in Pretoria, to determine approaches required for the reduction of water usage in major industries such as the textile, chemical, and food sectors. This concept is meant to provide a continuous application of environmental prevention strategies to production processes, products, and services with the overall aim of increasing efficiency and ensuring efficient resource and waste management practices. This in turn leads to improved cost savings, environmental performance and reduced risk to the environment and humans.

Textile effluent poses a considerable problem on a global scale especially in terms of its high salinity, high COD load, and colour. Efforts to minimise industrial discharge and manage wastewater are therefore essential. Best practices for wastewater management are summarised in Figure 20 and briefly outlined below, based on information obtained from the United States Environmental Protection Agency (project: EPA/625/R-96/004) and the European project, RESITEX (LIFE05 ENV/E/000285). These best practices range from optimising processes to minimise wastewater generation to taking into consideration the raw materials (e.g. dyes and process chemicals) and their impact on the quality of the wastewater generated.

Figure 20: A summary of best practices employed for the minimisation of wastewater generation and improvement of wastewater quality

Good management environmental practices

- Conduct research to see if it is possible to reduce the quantity and improve the quality of chemicals used.
- Regularly maintain and revise equipment, recipes and systems for automatic process parameter control.
- Re-use and recycle wastewater to reduce and optimise water consumption.
- Use flow charts and mass balances to evaluate the work flow of the textile production process.
- Manage stock efficiently to avoid expiry of chemicals used in different processes. These products are expensive and difficult to treat if used past their expiry dates.
- Minimise waste production by reducing the variability of the products used (i.e. generation of a waste stream with a consistent composition that can be treated).
- Implement a "zero waste" concept to minimise waste, by looking at the life-cycle of the product and incorporating the use of environmentally friendly materials and substances.
- Manage production by colour – this can be performed by producing lighter coloured textiles rather than dark coloured textiles. This will reduce washing machine requirements between different batch processes, thereby reducing effluent and water consumption.

Substitution and selection of chemicals used in the textile industry

- Replace conventional surfactants which have high toxicity with bio-eliminable and biodegradable surfactants.

- Replace nitrogen- and phosphor-containing complex agents with bio-eliminable and biodegradable compounds.
- Replace conventional printing pastes with compounds based on polyethylene glycol or polyacrylic acid, which is less harmful.
- Replace conventional antifoaming agents with products free of mineral oil, such as silicone which is more bio-eliminable.
- Reduce adsorbable organic halogen (AOx) compounds by replacing sodium hypochlorite with hydrogen peroxide in the bleaching process.
- Use less harmful carriers such as benzylbenzoate and N-alkylphthalimide as a substitute for conventional active substances that are based on chlorinated aromatic compounds.
- Use mixtures of aromatic sulphonic acids which are more bio-eliminable and hydro-soluble, and optimised products which are based on fatty acid esters, in place of conventional dispersing agents.
- New formulations free of sulphurs and polysulphurs can substitute for conventional sulphur-containing dyestuffs.
- Redue AOx further by using peroxides instead of oxide sulphur dyestuffs.
- Conventional rinsing may be substituted with dyeing wastewater and subjected to enzymatic treatment.
- Avoid the use of complexing agents and detergents during hot rinsing.
- Select textile dyes carefully to ensure minimal toxicity of wastewater generated.
- Avoid inorganic coagulants such as aluminium sulphate. Use other organic compounds to reduce the production of sludge in wastewater treatment plants.
- Use pigment printing pastes – these pastes have optimised environmental performance.

Product and resource recycling

- Minimise printing paste losses during rotary-screen printing by reducing the printing's volume paste supply system (such as the diameters of squeegees and pipes).
- Recover and recycle residual printing pastes.
- Use hydro-extractors and decantation equipment to recover and recycle anhydrous grease extracted from raw wool scour. This grease can be sold as a value-added product.
- Re-use the dye-bath when technically possible to minimise wastewater generation and recycle rinse water for the next reconstitution or dyeing step.
- Recycle glycol for the production of polyamides and polyesters.
- Use enzymes to recover and recycle bath desizing wastewater.
- During the cleaning of printing equipment, reduce water consumption by recycling the cleanest amount of rinsing water from the screens and squeegees, and by utilising a stop/start control when cleaning the printing belt.

- Combine tertiary treatments with membrane procedures to recycle wastewater.
- In comparison to normal evaporating systems, which use a great amount of energy, multi-effect evaporators could be used as a substitute to recuperate sodium hydroxide (NaOH) from washing steps. Multi-effect evaporators use less energy and increase process efficiency – about 25-45% of NaOH could be evaporated from effluents from washing steps after mercerisation.

New technologies and equipment

- Install dispensing and automated dosing systems to measure the exact amount of auxiliaries and chemicals required, to minimise wastewater generation.
- Combine scouring, bleaching and desizing in one single step for cotton woven fabrics, as well as for cotton blends containing synthetic fibres. This may be performed by incorporating new auxiliaries, automatic dosing, formulations and steamers which allow the "Flash Steam" procedure that makes use of alkaline cracking, pad-steam peroxide bleaching and telescope desizing in a single step.
- Introduce catalysed processes using enzymes for the treatment of wastewater. Traditional alkaline scouring treatment can be replaced by pectinases – this enzyme makes the substrate more hydrophilic which allows for increased bleachability. Amylglucosylases and amylases can be used as enzymatic desizing treatment.
- Use formaldehyde-poor, formaldehyde-free or "easy care" treatment cross-linking agents in the production of textiles.
- Drain and fill methods can substitute overflow-flood rinsing to reduce effluent generation and water consumption.
- Use liposomes as auxiliaries in the dyeing of wool. The use of liposomes allows for good dye-bath exhaustion for 40 minutes at 80°C. This helps save energy, reduces superficial damage to the wool fibre, does not require electrolytes, and reduces the COD load in the wastewater.
- Minimise wastewater further by using equipment that is fitted with temperature regulators, automatic controllers to determine filling volume, indirect cooling and heating systems, and doors and hoods to minimise vapour losses during dyeing processes.

Examples of best practice implementation: Company DF9

- *Chemicals used during bleaching are easily biodegradable, meeting European standard and EKO Tex requirements.*
- *All chemicals are used within 3 months, well before the expiry date.*
- *All dyes used have a fixation rate of 80-100%, which means less washes off, reducing the rinsing process and leaving less colour in the effluent.*
- *The antifoam used is oil-free, but more expensive.*
- *All chemicals used are formaldehyde-free.*
- *Rinsing water from the bleaching process is recycled and used in the printing process.*
- *Most of the chemicals are on a dispensing system, minimising wastage.*
- *The scouring and bleaching processes are combined.*
- *Using drain-and-fill methods rather than overflow-flood rinsing reduces effluent generation and water consumption. Ninety-five percent of the company's processes are drain-and-fill.*

Section 6: Energy use and management

6.1 Energy use in the textile industry

Energy consumption by the textile industry may be significant, depending on the types of processes in place. The most energy intensive processes are those used during wet processing, processes that require the production of steam, and drying and curing (IFC, 2007; Barclay and Buckley, 2002). Other systems that require energy include lighting and air-conditioning, (i.e. systems that assist with maintaining specific environmental conditions). The types of energy sources used by the textile industry and their specific use are summarised in Table 20.

Table 20: Energy sources used in the textile industry and their specific use (Barclay and Buckley, 2002)

Energy source	Use
Coal	Boiler fuel
Electricity	Equipment, air-conditioning, lighting, offices
Fuel oil	Boiler fuel, back-up for natural gas boilers, truck fleet
Propane	Back-up for natural gas boilers
Synthetic natural gas	Boiler fuel for steam production

Energy consumption benchmarks have been devised for the European Union (Table 21) and are typically broken down for the different processes that take place in the textile industry. All the companies who took part in this survey indicated that they do not monitor energy consumption for specific processes and could only provide total energy requirements (Table 22).

Table 21: Energy consumption benchmarks as defined for the European Union (IFC, 2007)

Process	Electrical energy (kWh/kg)	Thermal energy (MJ/kg)
Wool scouring	0.3	3.5
Yarn dyeing	0.8-1.1	13-16
Loose fibre dyeing	0.1-0.4	4-14
Knitted fabric finishing	1-6	10-60
Woven fabric finishing	0.5-1.5	30-70

Table 22: Energy sources and energy use by the textile companies who participated in the national survey

Company	Source of energy	Energy requirement	Annual cost (R)
Dyers and finishers			
1	Electricity	0.8 kWh/kg	Variable
	Steam from boiler	Not specified	
2	Electricity	6 916 kWh/month	1 294 800
	Refined oil	5 667 L/month	684 000
3	Electricity	21 473 kWh/month	360 000
4	Electricity	135 kWh/month	1 512 000-2 220 000
	Coal	190 ton/month	1 956 000-3 480 000
5	Electricity	Not specified	Not specified
	Coal	Not specified	Not specified
6	Illuminating paraffin	8 000-10 000 L/month	720 000-960 000
	Electricity	Not specified	240 000
7	Electricity	397 100 kWh/month	4 656 000
	Coal	270 ton/month	4 707 720
8	Electricity	Not specified	132 084
	Heavy fuel oil	Not specified	394 500
9	Gas	1 429 J/month	8 780 200
	Electricity	343 551 kWh/month	1 945 000
	Coal	1 993 ton/month	4 166 000
Producers			
1	Electricity	916 667 kWh/month	9 600 000
	Coal	19 800 ton/month	4 680 000
2	Electricity	52 952 kWh/month	806 989
	Heavy fuel oil	10 457 L/month	Not specified
3	Electricity	1.4-2 MWh/month	Not specified
	Gas	Not specified	Not specified
4	Electricity	2 MWh/month	Not specified
5	Not specified	Not specified	Not specified

Company	Source of energy	Energy requirement	Annual cost (R)
Technical and traditional textiles			
1	Electricity	1 290 MWh/month	12 000 000 (estimate)
	Coal	222 ton/month	1 884 000
	Heavy fuel oil	16 500 L/month	684 000
2	Coal	1 950 ton/month	28 800 000
	Heavy fuel oil	Not specified	240 000
	Electricity	3.2-3.6 MWh/month	30 000 000
	Gas	Not specified	1 800 000
3	Electricity	0.25 MWh/month	Not specified
	Coal	100 ton/month	Not specified
4	Heavy fuel oil	19 700 L/month	1 136 400
	Electricity	608 416 kWh/month	16 200 000
5	Thermal oil	21 309 L/month	1 276 608
	Electricity	155 965 kWh/month	2 461 260
	Coal	53.11 ton/month	964 848
6	Heavy fuel oil	Not specified	902 135
	Electricity	Not specified	235 421
7	Gas	210 L/metric ton	2 100 00
	Electricity	Not specified	Not specified

There are various options for the use of renewable energy in the textile industry. The successful use of solid waste as boiler fuel, and the use of solar, wind and geothermal energy, has been reported for companies in Germany, the USA, Brazil, Canada, China, Spain, the Philippines, and Iceland (Fibre2Fashion.com). For most companies, the high initial cost is often a deterrent. Of the 21 companies who took part in the survey, only one reported the use of a supplementary renewable energy source. Company P2 has implemented the use of solar power, which currently covers a third of the total power consumption of the company.

6.2 Best practice: Energy conservation

In 2015, the Natural Resources Defence Council (NRDC) published a report, covering various case studies, on the effect of implementation of best practices in the textile industry in China

(Greer et al., 2015). During the course of this study, the following best practices were identified:

Fuel best practices

- Recover heat from hot water – hot water used during dyeing, rinsing and finishing can be used to pre-heat incoming water. This will also decrease the temperature of the effluent water. Heat exchangers are required to achieve this.
- Annual calibration, the insulation of boiler casings and doors, and automated controls can improve boiler efficiency and thereby decrease energy requirements.
- Maintenance of steam traps and the steam system would prevent unnecessary energy requirements to maintain the same level of steam output.
- Insulate equipment and tanks.
- Recover heat from hot air.

Reduction in electricity consumption

- Optimise the compressed air system (fix leaks, optimise sizing, install control systems, general housekeeping).
- Optimise plant environmental conditions (decreases electricity required for air-conditioning); use energy-saving light fixtures.
- Shut off lighting, air-conditioning, etc. during shut-down periods.

Various ways to develop and implement more energy-efficient processes have been described by Hasanbeigi (2010), Barclay and Buckley (2002), and the Confederation of Indian Industry (2013) and are recommended reading for those interested in more detailed examples. Best practices currently being employed in the South African textile industry (or the lack thereof), are summarised in Table 23.

Table 23: Energy best practices currently employed in the South African textile industry

Company	Best practices implemented/comments
Dyers and finishers	
1	Targets in place to reduce energy use per kg Use of new energy-efficient equipment
2	No plan to implement best practices unless shown to be profitable Due to the current uncertainty of the status of the industry, the company is not likely to implement the use of renewable energy sources
3	No plan to implement the use of renewable energy – possibly in 10 years' time
4	Automated boiler to reduce coal usage and gas emission Considering the use of solar energy
5	Considering the use of renewable energy

Company	Best practices implemented/comments
6	Considered the use of solar energy, but not financially viable to implement at this stage
7	Working towards implementation of ISO 14001 Considering the use of alternative energy
8	No plan for implementing the use of renewable energy
9	Investigated the use of solar energy, but too expensive Looking at means to reduce use of equipment
Producers	
1	Moving towards implementing ISO 14001 Considering the use of green energy
2	Making use of solar power to cover a third of power consumption Making use of heat exchangers to reduce energy use/requirements
3	No plans for the use of renewable energy
4	Considering alternative energy, but will only implement if financially viable
5	Not specified
Technical and traditional textiles	
1	Currently implementing ISO 14001
2	Considering the use of alternative energy sources, but needs to be financially viable
3	No plans for the implementation of alternative energy
4	Changing to energy-saving lights to decrease electricity needs
5	No plans for the use of alternative energy sources Upgraded boiler system to a more energy-efficient one
6	No plans for the use of alternative energy sources, but have engaged with consultants on how to reduce energy needs
7	No plans for the use of alternative energy sources, but have implemented more energy-efficient processes and monitor energy consumption

Section 7: Other best practices in the textile industry

As described in this document, it is clear that the processes used in the textile industry require the input of raw materials (Section 1), water (Section 4), and energy (Section 6), for the production of a final product (Section 1). Along with the final product, wastewater (Section 5), solid waste and air emissions are also produced (Figure 21). Best practices with regards to water use, wastewater management, and energy were covered in the respective sections specified. In this section, we will briefly discuss the best practices recommended for the use of chemicals, how to manage air emissions, and best practices for managing solid waste.

Figure 21: A summary of the processes that take place in various industries

7.1 Best practice: The use of chemicals in the textile industry

Best practices with regards to the use of chemicals were partly discussed in section 5.4. It is important to note that not all chemicals used during the various textile preparation steps are retained in the fibres or materials produced. As such, these chemicals end up in the wastewater and can result in increased costs for pre-treatment of the wastewater prior to discharge (Entec UK Ltd., 1997). There are two main recommendations for best practices in chemical use:

1. Control the quantity of chemicals used;
2. Replace hazardous chemicals with those that are more biodegradable and/or can be easily eliminated from the environment without the generation of harmful secondary metabolites.

Chemical reduction

- Optimise the recipe to use amounts that would minimise the impact on effluent quality;

- Control the dosing by mixing or preparing chemicals using an automated system to ensure that there is minimal wastage and consistency in the amounts used;
- Maintain instrumentation to ensure that equipment is properly calibrated;
- Pre-screen the chemicals to be used in processes – consult the Material Safety Data Sheets to determine how safe the chemicals are and whether they are biodegradable;
- Change production scheduling to decrease the amount of equipment cleaning required by moving from lighter shades to darker shades in order to reduce water use for cleaning, reduce the amount of dyes required and the amount of effluent generated;
- Pre-screen the raw materials to be used.

Chemical substitution

- Replace hazardous chemicals with those that have a lower potential environmental impact. See ZDHC (2015) for details on hazardous chemicals that should be avoided.

In addition, companies can also invest in chemical recovery and re-use, e.g. dye solutions can be re-used, caustic substances can be recovered, and size (starch or PVA) can be recovered and re-used.

Of the 21 companies who took part in this survey, only one indicated the use of environmentally friendly chemicals (P3), one company is currently considering converting to the use of environmentally friendly chemicals (DF1), and a third indicated that caustic is recovered at a plant on-site (TT2). Several companies did however indicate that they are currently working towards implementing ISO 14001, which would require the implementation of more stringent approaches in the use of chemicals.

7.2 Best practice: Managing air emissions

The textile industry has the potential to generate significant air pollution depending on the type of chemicals used, the type of equipment used, as well as the type of processes in place. The air pollution can be classified according to point or diffusive sources – point sources include ovens, boilers and storage tanks; diffusive sources include wastewater treatment, spills, solvent-based and warehouses. The main sources of pollutants emanate from the use of solvents, formaldehyde, acids, and other volatiles. In addition, dust, noxious gases and oil mists may be generated during the processing of raw materials, while exhaust gases may be generated by certain types of equipment, such as coal-fired boilers (IFC, 2007).

- To minimise dust, equipment can be enclosed, a dust extractor can be used, and/or fabric filters can be installed;
- Noxious gases and exhaust fumes can be removed via exhaust ventilation and the use of emission control techniques, e.g. chemical scrubbing;
- Volatile organic compounds and oil mists can be minimised by using equipment with reduced solvent use, using water-based methods to remove oil and grease, using less

toxic solvents, recovering volatile organic compounds via vapour-recovery units, and using control techniques, e.g. use of activated carbon absorbers.

Most of the companies interviewed during the course of this survey acknowledged the production of emissions (mostly from boilers), but in most cases, emissions are not monitored or managed. TT1 indicated that most of its air emissions are generated during the drying process used during textile production. The emissions are monitored in terms of volume and toxicity to minimise impact (no data provided). Company P2 monitors its chimneys for carbon dioxide emissions and ensures low emissions by constantly maintaining the boiler burners. Company TT3 indicated that it only monitors air quality every two years, and based on the outcome of the inspection, implements recommendations for correction.

7.3 Best practice: Managing solid waste

The textile industry generates both toxic and non-toxic solid waste. Solid waste, as with all other waste generated, varies, depending on the type of processes used, the type of equipment used, and the type of chemicals used in the preparation of the textiles. Typical solid waste includes textile waste (e.g., raw material and fibres, cut-offs, defective items, etc.), sludge from wastewater treatment, chemical waste (including the containers the chemicals are supplied in, etc.), and office waste.

Some recommendations for the minimisation of solid waste (Barclay and Buckley, 2002):

- Reduce the amount of packaging material by ordering raw materials in bulk and/or in returnable containers;
- Purchase chemicals that can be delivered and stored in returnable containers;
- Purchase chemicals that can be delivered and stored in containers rather than bags to minimise the possibility of spillages;
- Sell waste fibres and scraps to other companies for use in the production of other products;
- Optimise wastewater treatment steps to minimise sludge production.

The best practices employed by the 21 companies who formed part of this national survey, are summarised in Table 24.

Table 24: Solid waste best practices employed in the SA textile industry

Company	Main type of waste generated	Best practices implemented/comments
Dyers and finishers		
1	Fabric strings and off-cuts	Bulk sold to individuals for re-use Remainder of waste sent to landfill No re-use of waste from dyeing and printing
2	Mainly fluff	Sent to landfill

Company	Main type of waste generated	Best practices implemented/comments
3	Cuts, screenings, leftover material and paper waste (average of 50 kg/day)	Paper is recycled Rest of waste sent to landfill
4	Cardboard, plastic, and ash from the boiler (ash: 100 ton/month)	Cardboard and plastic are recycled Ash sent to landfill
5	Not indicated	All waste sent to landfill No plan to re-use waste
6	Salt bags	Collection of waste by Wastetech
7	2.5% of raw material ends up as waste	Waste is sold to customers who use it as raw material for other products Contaminated waste is removed by an accredited company
8	Not indicated	No re-use of solid waste
9	Used drums, fabric off-cuts	Off-cuts are sold for use in other products Rest of waste is sent to landfill No re-use planned
Producers		
1	Average of 40 kg/ton of fabric is wasted (approx. 4% of raw material)	Sell the waste to customers who use it as raw material for other products
2	Yarn, plastics and cardboard	Glass, metals, plastics and cardboard are recycled Used/waste yarn is sold for making punching bags Used/waste yarn donated to Beads for Africa to support HIV+ mothers
3	Minimal waste produced (<20 kg/ton)	Waste disposed to landfill No plan to re-use waste
4	<50 kg waste generated/week	Some waste collected and used by outside individuals Most waste is sent to landfill No plan to re-use waste
5	Not indicated	Not indicated
Technical and traditional textiles		
1	Waste generated: 36 g/m fabric produced	Most material is recycled, minimal disposal to landfill
2	Alum, fabric waste, coal ash, scrap (approx. 200 kg/week)	Sell fabric waste to customers for re-use Rest of the waste to landfill
3	Fibres and off-cuts	Fibres are dispersed in wastewater effluent Cuts are sold to recyclers

Company	Main type of waste generated	Best practices implemented/comments
4	Leftover yarn, plastics	Yarn is used by outside company for production of cushions and pillows Plastics are recycled Try to avoid sending waste to landfill
5	Leftover yarn, off-cuts, yarn pieces, fluff	Try to re-claim for re-use Cardboard waste and plastic waste is minimal and is recycled
6	Fabric off-cuts, cardboard, plastics	Cardboard and plastics are recycled Fabric off-cuts are sold to companies who re-purpose the off-cuts
7	Dried dip solution (approx. 100 g/ton textile produced)	Collected by Enviroserv and disposed of, no potential for re-use

A success story: *Company P2 set itself a "zero landfill" objective. In 2001, 825 m^3 of waste had to be removed from the company at a cost of R136 800. By continuously trying to find ways of minimising and re-purposing their waste, solid waste collected in 2014 was down to 25 m^3 (removed at a cost of R2 952, a 98% reduction in cost). The company recycles glass, metal, plastics and cardboard (proceeds goes to a nearby school) and they support initiatives such as "Beads for Africa". A part of the company's success can also be attributed to its participation in the Western Cape Industrial Symbiosis Programme (WISP), which encourages various companies from different sectors to connect to determine whether unused or residual resources from one company can be used by another. This initiative has not only resulted in economic and social benefits, but has resulted in decreasing the environmental impact of the participating companies through the drastic decrease in solid waste sent to landfill.*

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Useful Websites

Africa Silks
http://www.africasilks.com
Brand South Africa
http://www.brandsouthafrica.com
Cape clothing and textile cluster
http://www.capeclothingcluster.org.za/
Cape Wools SA
http://www.capewools.co.za
Cotton South Africa
http://www.cottonsa.org.za
Fibre2Fashion - B2B Marketplace connecting textile, apparel, fashion suppliers & buyers globally
http://www.fibre2fashion.com/
KwaZulu Natal clothing and textile cluster
http://www.kznctc.org.za/home-page
Manufacturing industries in South Africa
http://www.southafrica.info/business/economy/sectors/manufacturing.htm#textiles
South African technical textile cluster
http://www.satechnicaltextilecluster.co.za
Textile federation of South Africa
http://www.texfed.co.za/

ANNEXURE 1

WATER RESEARCH COMMISSION

Water Research Commission
Marumati Building,
491 18th Avenue, Rietfontein, Pretoria

Private Bag X03, Gezina, 0031, South Africa

Tel: +27 (0)12 330 0340
Fax: +27 (0)12 331 2565
Email: info@wrc.org.za
Web: www.wrc.org.za

03 October 2014

Dear Sir/Madam

Re: National Survey (Natsurv) of Water and Wastewater Management of Industries

In 1985 the Water Research Commission, in collaboration with the Department of Water Affairs and Forestry (now the Department of Water and Sanitation), commissioned a national industrial water and wastewater survey of all classes of industry in order to ascertain the minimum water requirements (specific water intake) of particular industries, as a blanket restriction in times of drought would be grossly unfair. Furthermore, the study also surveyed the wastewater and typical pollutant loads generated which allowed regulators to manage discharge to sewers thus protecting infrastructure and the downstream treatment processes. These surveys resulted in the publication of a series of 19 NATSURV guidelines on water and wastewater management for the different industrial categories between 1987 and 2005 (see list below). The Natsurv reports for different industries have been used extensively by the sector since they were developed. Most of the guides have been incorporated in courses presented by universities and universities of technology and are widely used by the sector to make informed decisions regarding industries.

There is increasing consensus that South Africa is a water stressed country and some areas could even be defined as water scarce. As the demands on water systems increase, the impact on the social, environmental and economic systems they support become more stressed and the responses become more uncertain and unpredictable. For economic development, a major dimension is the relationship between water management by government, the manner in which water is used, and water-associated risks dealt with by the private sector which forms the engine of the economy.

South Africa and its industrial sectors have either grown or in some cases shrunk considerably since the 1980's. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries, and therefore, certain information contained in the national surveys can be regarded as obsolete. Furthermore, initiatives like the UN CEO mandate, water stewardship, water allocation and equity dialogues, amongst others suggests growing awareness by industry related to: water use, water security, and waste production. Thus, it is considered an opportune time to review the water and wastewater management practices of the different industrial sectors and make firm recommendations.

The WRC is currently revising all 19 Natsurvs and have included a new national survey for the Steel industry. This is a process that commenced in 2013 with 4 studies supported per year and the aim is to complete all current revisions by 2019. The revision has the support of the Department of Water and Sanitation.

We therefore encourage industries that are approached by the researchers for data and information to support this process as this will ensure that right information is captured. In addition, your support is important for the following reasons:
a) The report can be used by industries to benchmark their practices
b) The report will introduce to industry new concepts of water and wastewater management
c) The report will allow regulators and industries to engage in informed discussions as it will provide a national overview.

Yours sincerely

Dr Valerie Naidoo
Research Manager

WRC Natsurv Reports:

1. Malt Brewing
2. Metal Finishing
3. Soft Drink
4. Dairy
5. Sorghum Malt and Beer
6. Edible Oil
7. Red Meat
8. Laundry
9. Poultry
10. Tanning and Leather Finishing
11. Sugar
12. Pulp and Paper
13. Textile
14. Wine
15. Oil Refining and Re-refining
16. Power Generating
17. Fruit and Vegetable Processing
18. Pelagic Fishing
19. Fish Processing
20. Steel (NEW!)

Note: These report can be downloaded from the WRC website fee of charge: www.wrc.org.za

ANNEXURE 2

Site visit interview questionnaire

Interviewer:	Interviewee:	....
Date:	Position:	....
	Contact	....
	Company:	....
	Province:	....

Question	Response
1. Material used (types and volume)	
What type(s) of textile(s) is produced by this company?	
What raw materials do you use to manufacture textile?	
How old is the current production equipment used?	
Can you provide me with the production statistic (e.g. 5 years)	
2. Frequency of use (seasonality)	
Is the textile production seasonal? If yes, please elaborate.	
3. Production process	
What process is used to produce textiles? Please describe.	
4. Water usage and management	
What is/are the source(s) of water used in the production chain?	
What is the volume of water used per ton of product?	
Can you specify water usage per production process?	
Could you provide us with your monthly water tariffs?	
Do you have any water usage target in place? Please specify.	
How do you manage water usage?	
5. Wastewater generation and management	
What volume of wastewater is generated during the production process?	
Do you determine the volume of each source of wastewater?	
Do you treat wastewater effluent prior to discharge?	
Do you test the quality of wastewater prior to discharge?	
What parameters do you measure? Can you provide us with historical data?	
Do you reuse wastewater effluent? If yes for what purpose?	
6. Solid waste generated	
Does the textile production process produce solid waste?	
Can you estimate the volume of solid generated per ton of textile produced?	
How do you manage the solid waste generated?	
Any prospect of reusing solid generated from textile production?	
7. Emissions	
Are gaseous emissions generated during the production processes?	
8. Energy usage	
What type(s) of energy is/are used in the textile production processes?	
Can you provide details of the energy requirements? Quantity?	
What is the average monthly energy costs breakdown?	

9. Adoption of green principles	
What are you doing to prevent potential pollution from the production process?	
Do you have any plan to use green energy?	
10. Any comments	

Closing questions

	Yes	No
Would you allow the name of your company to be acknowledged in this report?		
Would you like to receive a copy of this report and comment prior to publication?		
Would you allow us to collect wastewater and solid samples?		
Would you or a delegate from your company be interested in participating in the workshop that will be held in coming months?		
Would you like to recommend any other companies you feel may be interested in taking part in this research? If yes, name of company:		

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