Exploring the challenges associated with the greening of supply chains in the South African manganese and phosphate mining industry

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As with most mining activities, the mining of manganese and phosphate has serious consequences for the environment. Despite a largely adequate and progressive framework for environmental governance developed since 1994, few mines have integrated systems into their supply chain processes to minimise environmental risks and ensure the achievement of acceptable standards. Indeed, few mines have been able to implement green supply chain management (GrSCM). The purpose of this article was to explore challenges related to the implementation of GrSCM and to provide insight into how GrSCM can be implemented in the South African manganese and phosphate industry. This article reported findings of a qualitative study involving interviews with 12 participants from the manganese and phosphate industry in South Africa. Purposive sampling techniques were used. Emerging from the study were six themes, all of which were identified as key challenges in the implementation of GrSCM in the manganese and phosphate mining industry. From the findings, these challenges include the operationalisation of environmental issues, lack of collaboration and knowledge sharing, proper application of monitoring and control systems, lack of clear policy and legislative direction, the cost of implementing GrSCM practices, and the need for strong leadership and management of change. On the basis of the literature reviewed and empirical findings, conclusions were drawn and policy and management recommendations were accordingly made.

Introduction

Background

Until the late 1980s, when the notion of sustainable development surfaced (World Commission on Environment and Development 1987), it was generally held that economic growth would inevitably lead to environmental degradation through the consumption of non-renewable resources, the overuse of renewable resources and the production of waste and pollution (Dryzek 1997:20). This thinking was out of sync with the principles underpinning the notion of sustainable development, defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development 1987:43). Environmental impacts resulting from industry are represented by emission inventories of chemical release to the air, water and soil (Hagelstein 2009:3738).

The environmental degradation resulting from economic activities led some policymakers and scholars, such as Beamon (1999:332), to join in calls for a need to change manufacturing philosophy. Inevitably, this would have a bearing on supply chain management. For many years, the concept of supply chain management focused on enhancing operational efficiency and minimising waste – not so much for environmental reasons, but for economic reasons (Svensson 2001:866). Essentially, the goal of supply chain management was about cost reduction, transportation and storage efficiencies, whilst service enhancement came from better delivery performance and fewer stock-outs for the retailer (Finch 2008:393). According to Ganeshan and Harrison (1995:1), the supply chain is a network of facilities and distribution options that perform the function of procurement of materials, transportation of these materials into intermediate and finished products to customers and also involves extraction and exploitation of natural resources (Srivastava 2007:53).

Like never before, the environment has become critical in the management of supply chains; hence, the notion of green supply chain management (GrSCM) has gained acceptance. Hui, Chan and Pun (2001:269) indicate that government policies and pressure from groups fighting for the protection of the environment are some of the factors that induce business enterprises to adopt a green manufacturing or environmental system policy. This issue is setting guidelines for healthy living, doing business, generating products, extracting raw materials, recycling and reusing materials and reducing waste and energy, thus reducing the use of virgin materials and saving them for future generations (Muduli & Barve 2011:484). Organisational sustainability involves 'a wise balance among economic development, environmental stewardship, and social equity' (Muduli & Barve 2011:485). Amongst other things, environmental stewardship involves effective management of sewage effluents, sedimentation of river and other stored water bodies, leachates from wash-off from dumps, solid waste disposal sites, broken rocks, cyanide and other toxic chemicals waste release, salinity from mine fires and acid mine drainage.

Srivastava (2007:53) defines GrSCM as the integration of environmental thinking and supply chain management, including product design, material sourcing and selection, manufacturing process, delivery of the final product to the consumer and the end-of-life management of the product after its useful life. According to Gilbert (2001:1), GrSCM is the process of incorporating environmental criteria or concerns into purchasing decisions and long-term relationships with suppliers. In this regard, Engel (2008:1) observed that, in general, South Africa has made significant progress with environmental management in the last decade by implementing laws and strategies that focus on sustainable development and green issues.

The purpose of this article is to explore challenges related to the implementation of GrSCM and to provide insight into how it can be implemented in the South African manganese and phosphate industry. To this end, the article will first review the literature, then discuss the research strategy and methodology employed, followed by the presentation of the research findings before conclusions are drawn and recommendations made.

Literature review

This section of the article presents an overview of the manganese and phosphate mining industry and the implementation of a green supply chain in South African industry. The section also provides insight into the constraints, challenges and benefits associated with minimising environmental risk in the mining process from exploration stage to mine closure.

An overview of the manganese and phosphate mining industries

Manganese is largely consumed by the steel-making industry in South Africa, mainly in the building and construction industry. The trend is similar globally with the construction industry as the largest consumer, followed by machinery and transportation (Hagelstein 2009:37). The continuing rise in the worldwide demand for steel, and consequently manganese, means that demand for increasingly higher quantities of manganese are expected. This demand is mainly concentrated in two countries, China and India (Gajigo, Mutambatsere & Adjei 2011:8). According to Gajigo *et al.* (2011:23), there are five manganese mining companies that operate in South Africa: BHP Billiton (Samancor Manganese), Assmang Limited, Kalagadi Manganese, Tshipi Manganese and United Manganese of Kalahari (UMK). BHP Billiton (Samancor Manganese) is the world's largest manganese producer, whilst Assmang Limited is fourth. Together, Assmang and BHP Billiton (Samancor Manganese) account for 80% of manganese production in South Africa, dominating the local market (Gajigo *et al.* 2011:23). Smaller producers are Metmin and National Manganese Mines (Department of Minerals and Energy 2005:14).

The need for phosphate mining in South Africa was triggered by the manganese and phosphate industry, initially based on sulphuric acid, a by-product, and which imported rock phosphates. In 1919 and 1921, Kynoch, an explosives producer, and Cape Explosives (originally De Beers Explosives), respectively, started phosphate production. The industry flourished in a protected trade environment and government support for agriculture in general. This led to the development of Sasol, Iscor (now Arcellor Mittal) and Foskor in the early 1950s (Van der Linde & Pitse 2006:2). A recent study by Trujillo (2012) confirms that phosphates are also used in the production of special glasses, such as those used for sodium lamps (used in street lights).

The four largest net consumers of phosphate – using it for the production of fertilisers – include China, the USA, India and Brazil, all of which are large countries with a substantial agricultural sector (Van Enk *et al.* 2011:2). In South Africa, the commercially important phosphate deposits are confined to igneous and marine sedimentary geological environments. The former environment is by far the most important in South Africa, in that roughly 95% of the country's production comes from the Phalaborwa complex in the north-eastern Transvaal (now Limpopo Province) (Roux *et al.* 1989:129). Apart from Phalaborwa, there are a number of other carbonatic complexes in South Africa and its neighbouring territories that have been mined for phosphate, or are potential phosphate sources. The Glenover complex mine is another location in South Africa where phosphate mining occurs (Roux *et al.* 1989:129). Other players within the phosphate mining industry are Schiel and Langberg.

There is a significant relationship between manganese and phosphate. This relationship involves non-renewable resources, elements used in the same products which have isolated reserves and the consequent political implications. Some studies show that manganese is as abundant as phosphate (Emsley 2001:249). A combination of phosphate, magnesium and ammonium struvite contains many of the essential nutrients that plants need (Gilbert 2009:716). Manganese and phosphate play an important role in food security globally (Cordell, Drangert & White 2009:295; Jhanji *et al.* 2014:650). According to Van Enk *et al.* (2011:7), modern agriculture relies heavily on phosphate additions to animal feed and the application of phosphate fertilisers for crop production, which makes phosphorus an essential constituent of the global food market. Corathers (2009:100) adds that the manganese compound, manganous chloride ($MnCl_2$), is an additive in animal food for cows, horses, goats and other domestic animals. Fertilisers also contain manganous chloride which ensures plants get all the manganese they need (Corathers 2009:100).

Furthermore, the manganese and phosphate industries both support the steel industry. For example, phosphorus is used as an additive in steel to improve machining characteristics and atmospheric corrosion resistance (Roberts, Krauss & Kennedy 2004:4) and, according to many reports, including that of Global Industry Analysts (2012), the addition of manganese to steel makes the final product hard and resistant to corrosion (rusting) and mechanical shock. Both manganese and phosphate are also used in building materials, where manganese is used in brick colourant and steel structures, the match-making industry, transportation and the beverage industry, to list a few.

Supply chain management

The traditional supply chain is defined as an integrated manufacturing process in which raw materials are manufactured into final products, then delivered to customers, through distribution, retail, or both (Beamon 1999:336). Supply chain management includes product development, management of information systems, production control, quality control, customer service and recycling and waste management (Koskinen & Hilmola 2008:211). The Council of Supply Chain Management Professionals (2014) describes supply chain management as follows:

> Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers and customers. In essence, supply chain management integrates supply and demand management within and across companies. (p. 1)

Another study by Jain and Benyoucef (2008:469) describes successful future supply chain features as:

- strategies, technologies, people and systems
- environmental protection as the global ecosystem will always be strained by growing population and the emergence of new high-technology economies
- re-engineering the lean, agile, flexible, demand-chain management and integrated supply chain scheduling issues for long supply chains.

Green supply chain management

As environmental issues are becoming an important element in the task of management, there are good reasons to believe that this new development is likely to be more than a passing trend. Relevant work is emerging from a number of sub-disciplines, once considered a subset of health and safety (New, Green & Morton 2002:93). Increasingly, the environment is seen as pertinent to the work in distribution logistics, product and process design, operations strategy and procurement and supply chain management (New *et al.* 2002:93). Although business enterprises in most industrialised countries have adopted environmental protection practices required by government agencies since the early 1970s, these regulations largely focus on, for example, the control of water and air emissions and waste disposal (Morrow & Rondinelli 2002:161).

The new environmental era represents a new challenge to manufacturing and production enterprises worldwide. The challenge is to develop ways in which industrial development and environmental protection can coexist symbiotically (Beamon 1999:336). With increasing awareness of environmental protection worldwide, the green trend of conserving the earth's resources and protecting the environment is overwhelming (Chien & Shih 2007:383). The notion of a green supply chain has emerged in the last few years and covers all phases of a product's life cycle from design, production and distribution phases to the use of products by the end users and their disposal at the end of the product's life cycle (Luthra *et al.* 2011:232). Green supply chains aim to confine the wastes within the industrial system in order to conserve energy and prevent the dissipation of dangerous materials into the environment (Luthra *et al.* 2011:233).

Rettab and Ben Brik (2008) define GrSCM as a managerial approach that seeks to minimise a product or service's environmental and social impact or footprint. According to Gilbert (2001:1), GrSCM is the process of incorporating environmental criteria or concerns into purchasing decisions and long-term relationships with suppliers. The ultimate objective of extending the traditional supply chain is to allow consideration of the total immediate and eventual environmental effects of all products and processes (Beamon 1999:336). Thus GrSCM is integrating environmental thinking into supply chain management (Luthra *et al.* 2011:232). Green supply chain management – also known as environmental supply chain management, or sustainable supply chain management (Seuring 2004:1059) – combines green purchasing, green manufacturing and materials management, green distribution and marketing and reverse logistics (Sarkis 2005:330; also see Chien & Shih 2007).

Green supply chain management practices include reducing energy consumption, recycling and re-use, using biodegradable and non-toxic material, harmful emissions and eliminating waste (Duber-Smith 2005:24). According to Stevels (2002:6), GrSCM leads to lower environmental load and reduced consumption of resources for society. Green supply chain management seeks to minimise the undesirable environmental impact of the supply chain process within participating organisations (Zanjirani Farahani, Asgari & Davarzani 2009:197).

Legislative context

Mining legislation, in particular, determines the manner in which mining operators should behave and it also, in the long run, influences the level of investment in the sector. In South Africa, the Constitution has included clauses aimed at protecting the environment for the benefit of future generations (Republic of South Africa 1996). The general administration of the industry falls under the Department of Minerals and Energy. The most important pieces of legislation for the industry are the *Minerals Act* (Act 50 of 1991) (Republic of South Africa 1991) and the *National Environmental Management Act* (Act 107 of 1998) (Republic of South Africa 1998). Most regulations affecting the industry are made under these pieces of legislation. Under the *Minerals Act*, mines are required to have an environmental management plan (EMP), which must be approved by the Department of Minerals and Energy. The aim of the EMPs is to regulate the industry from the start to the end and to assist businesses in complying with the law.

An EMP describes the pre-mining environment, the aim and description of the project, the environmental impact assessment and an indication of how the impacts will be managed. Once approved by the Department of Minerals and Energy, the EMP becomes a legally binding document. If and when the EMP is violated, it is cause for suspension or withdrawal of the mining licence or even prosecution of the licence holder (South African Resource Watch 2012). The other important piece of legislation required by mining operators is the water permit, which regulates water use and discharge. This must be obtained from the Department of Water Affairs. The water permit is important because one of the major operations in mining is dewatering, tailings management and the management of dust and other emissions.

Many possibilities exist to reduce the environmental burden of mining activities (Muduli & Barve 2011:486). A firm needs to find the right processes to manage environmental issues in a manner that is consistent with its long-term interests. The appropriate processes are different for every firm and there are no ready answers as to which processes are appropriate under what circumstances. Therefore, a good framework can help managers find the appropriate processes by providing a way of structuring their thoughts (Corbett & Van Wassenhove 1993:118; also see Tsoulfas & Pappis 2006).

The potential for great opportunities and profit has been recognised by many who have called for extended producer involvement and responsibility. This involvement has appeared in calls for the provision of a product as a service, or for manufacturers to provide a series of services to support and supplement the sale of the original product (Wise & Baumgartner 1999:133). Pursuing the green manufacturing of products is very beneficial to the alleviation of environmental burdens (Chien & Shih 2007:385). Business enterprises use the local legislation as a minimum standard with which they comply whilst striving towards best international practices as far as is practicable. For example, local legislation requires all manganese operations to keep all exposure longer than 8 hours per day below 1 mg/m^3 – responsible businesses are working towards level of 0.2 mg/m^3 (Grimbeek 2010:1).

Challenges associated with green supply chain management

Cost has been used as one of the prime reasons not to implement GrSCM. Granted, the initial investment requirement by green methodologies, such as green design, green manufacturing and green labelling of packaging, may prove to be too high (Shi *et al.* 2012:60). Engaging in environmental management involves two types of costs: direct cost and transaction cost (Luthra *et al.* 2011:239). King and Lessidrenska (2009:180) urge that even when under financial stress, organisations should not neglect sustainable development, as such times could well be the best times to prepare for the future, whilst it may also prove to be a method of building goodwill in order for the business to thrive through crisis. Yet, the cost of avoiding the implementation of GrSCM may be even higher, as Beamon (1999:337) reflects:

- cost avoidance of purchasing hazardous materials as inputs, which reflect the internalised costs associated with environmental harm
- cost avoidance of storing, managing, and disposing process waste, particularly as waste disposal becomes increasingly expensive
- cost avoidance of stigmatisation or market resistance to environmentally harmful products
- cost avoidance of public and regulatory hostility towards environmentally harmful organisations.

According to Chien and Shih (2007:387), environmental protection activities can have a positive effect on a business enterprise's financial performance. Tsoulfas and Pappis (2006:1593) agree that a sustainable approach can lead to internal cost saving, open new markets and find beneficial uses for waste. Zhu and Sarkis (2004:270) also hold the view that GrSCM can cut the cost of materials purchasing and energy consumption, reduce the cost of waste treatment and discharge and avoid a fine in the case of environmental accidents. Another factor that contributes to enterprise compliance is to strengthen relationships with suppliers, resulting in lower inventory levels, costs and higher accuracy. Involvement of the suppliers in the design process and technology affects overall performance of a whole chain (Sarkar & Mohapatra 2006:148).

Using less energy, for example, is good for the environment as it is for the business as it cuts their costs and eventually avoids potential environmental liabilities (Kot & Grabara 2009:59). It is therefore a prerequisite to the long-term sustainability of business. To replace non-renewable and polluting technologies, it is crucial to support the use of renewable energy resources, as well as to reduce energy consumption (Tsoulfas & Pappis 2006:1597). Innovative green practices are associated with the explicitness of green practices, the accumulation of green-related knowledge, organisational encouragement and quality of human resources (Yu Lin & Hui Ho 2008:19).

Whilst some studies have found that an increased emphasis on sustainability in the supply chain is related to lower costs and a neutral or positive effect on value (Rao & Holt 2005:899), others have identified trade-offs between what is economically rational for supply chain members and what is of greatest value to the entire system or population (Walley & Whitehead 1994:3). Extending the supply chain to include issues such as remanufacturing, recycling and refurbishing adds an additional level of complexity to existing supply chain design in addition to a new set of potential strategic and operational issues, which, in turn, can increase costs, at least in the short term. Two basic problems give rise to these issues, (1) the uncertainty associated with the recovery process with regards to quality, quantity and timing of returned products, containers, pallets and packaging and (2) the collection and transportation of these products, containers, pallets and packaging (Linton, Klassen & Jayaramann 2007:1079).

Today's most successful manufacturers have tight coordination with their supply chain partners, enabling real-time information to travel immediately up and down the supply chain and a well-coordinated movement of inventories (Sanders 2007:1334). Suppliers contribute to the overall performance of a supply chain and poor supplier performance affects the performance of the whole chain (Sarkar & Mohapatra 2006:148). Supplier–manufacturer relationships are considered important in developing a sustainable competitive advantage for the manufacturer (Sheth & Sharma 1997:91; also see Chien & Shih 2007). Clark (1999:14) adds that screening of suppliers for environmental performance has now become a key deciding factor in many organisations. Environmentally responsible manufacturing processes, GrSCM practices and their many related principles have become important strategies for businesses to achieve profit and increase market share objectives by lowering their environmental impact and enhancing efficiency (Zhu & Sarkis 2006; also see Chien & Shih 2007).

Research method and design

Research approach

Owing to its exploratory nature, a qualitative approach was chosen for this study. Qualitative research collects descriptive, non-numeric data that are likely to describe something, such as what a person sees in a picture or type of behaviour to which a person might react (Christensen, Johnson & Turner 2010:434). In order to meet the objectives of the study, exploratory and descriptive design strategies were used. Qualitative research methods provide researchers with the flexibility and freedom needed to explore phenomena where the literature is lacking and thus help to highlight important variables for future research (Leedy & Ormrod 2010:2).

Hence this study strove to provide an in-depth understanding of the implementation of GrSCM in the South African manganese and phosphate mining industries.

Selection of participants

The 12 participants were selected using purposive sampling. These participants were selected on the basis of their positions and expert knowledge within the manganese and phosphate industry (Devers & Frankel 2000:264) (see Table 1).

According to Neuman (1997:205), purposive sampling is based on the researcher's knowledge of a research area and the important opinion-makers within it, whilst relying on the researcher's ability to make a sound judgement on which of these opinion-makers to approach. In this case, the researcher's knowledge of the South African manganese and phosphate mining industries and other role players in the industries enabled the researcher to approach the high profile individuals to participate in the study.

Data collection

Primary data were collected using semi-structured interviews, whilst secondary data constituted the literature reviewed throughout the study, internal publications provided by participants and publicly available data relevant to the topic being observed. A semi-structured interview is flexible, allowing new questions to be brought up during the interview as a result of what the interviewee says (Goddard & Melville 2005:49). Open-ended questions were used during the interview in order to elicit in-depth information on the constraints and successes of implementing a green supply chain in the South African manganese and phosphate mining industries.

Data treatment

In qualitative research, recording of data can be performed in various ways, including taking notes and using electronic devices such as tape recorders, video recorders or digital voice recorders. According to Boeiji (2010:3), when data are collected from multiple sources, a neat archive is essential to store the data to enable easy retrieval. In this study, a digital voice recorder and note taking were used to record proceedings of the interviews. Some of the participants used reports and presentations to elaborate further on some of

TABLE 1: Organisations from which the respondents were surveyed.

Case Study	Name of organisation	Number of respondents interviewed
1	Foskor Ltd	1
2	Assmang Ltd	1
3	Samancor Manganese (Pty) Ltd	2
4	Tshipi-e-Ntle	1
5	Kalagadi Manganese (Pty) Ltd	2
6	United Manganese Mines (UMK)	1
7	South Africa Chamber of Mines	1
8	Mining consulting houses	2
9	Department of Environmental Affairs and Tourism	1
Total	-	**12**

the points during the interview. The observations on body language were recorded in the field notes immediately after the interviews. Each recorded interview was transcribed, reviewed, combined with field notes and analysed. The data were analysed until saturation point, when themes continued to emerge repeatedly from the transcripts.

Trustworthiness

In qualitative research, trustworthiness consists of four elements: credibility, transferability, dependability and confirmability. In this study, credibility and dependability were chosen as the key measures of the study's trustworthiness.

Credibility

Credibility deals with the accuracy of data to reflect the observed social phenomena, this means it focuses on whether the study measures or tests what is intended. Credibility is concerned with the fieldwork or data collection phase when the completeness and accuracy of the interview responses (Roller 2012:2). After each and every interview, a follow-up communication was sent out by email regarding the contributions and for clarification, showing a portrayed understanding and credibility of the research process.

Dependability

The idea of dependability emphasises the need for the researcher to account for the ever-changing context within which research occurs. Hammersley (2008:67) adds that dependability relies on the participants' collaboration in contributing credible, applicable and valid data which are sorted through triangulation. The environmental audit reports and figures provided by the participants from the manganese and mining industries in South Africa and their role players, such as external consultants, confirms the dependability of the data collected.

Discussion of the results

The results indicated that whilst there is recognition of the need to implement GrSCM practices within the manganese and phosphate mining industry, there remain challenges associated with the implementation of such practices. These challenges include the operationalisation of environmental issues, lack of collaboration and knowledge sharing, proper application of monitoring and control systems, lack of clear policy and legislative direction, the cost of implementing GrSCM practices and the need for strong leadership and managing change. These challenges are discussed below.

Operationalisation of environmental issues

Mining practices will remain for as long as there are minerals available for extraction. The long-held view has been that economic growth would inevitably lead to environmental degradation through the consumption of non-renewable resources, the overuse of renewable resources and the production of waste and pollution (Dryzek 1997:20). According to the literature, economic and social development is in the interests of the mining industry, but the third pillar of sustainable development, namely environmental protection, appears to be of least importance (Muduli & Barve 2011:484). The respondents indicated that they are aware of the environmental concerns associated with their mining operations, such as the toxins that are released from the air, water and soil during their mining operations. The respondents further indicated that as long as the environmental concerns are not incorporated as part of the scope at the level of specifications by the users, it is difficult for procurement to buy green. Thus, the main challenge for respondents seems to be the *lack of operationalisation of environmental issues in areas such as procurement*.

Lack of collaboration and knowledge sharing

The industries require the commitment of all stakeholders to enhance environmental management capabilities by providing training programmes and sharing their green system. Knowledge sharing in a green supply chain leads stakeholders to develop new capabilities for effective actions. Training and education are the prime requirements for achieving successful implementation of GrSCM in any organisation, whilst informal linkages and improved communication help the organisations to adopt green practices (Ravi & Shankar 2005:1016).

Information technology has made possible the sharing of large amounts of information along the supply chain, including operations, logistics and strategic planning data. This has enabled real-time collaboration and integration between supply chain partners, providing organisations with forward visibility, improving production planning, inventory management and distribution (Sanders 2007:1332). All operating manganese and phosphate mining companies have adopted one form of enterprise resource planning system or another. These include SAP, JD Edwards, Pastel and Syspro.

It was found from the respondents' comments that users prefer to use suppliers with which they have always worked and they are reluctant to use new suppliers who might comply better with the environmental requirements. Hence, users are not exposed to fresh ideas in terms of more improved product offerings. Thus, *lack of collaboration in sharing knowledge* amongst the stakeholders is another challenge in the implementation of a green supply chain in the industries. The respondents are convinced that should they collaborate amongst themselves so that they can share information from their respective competencies about new processes, plants introduced in the market and the ever-changing technologies.

Proper application of monitoring and control systems

Respondents see pollution as an inherent part of doing business in the mining industry. Another respondent went as far as saying that in order to stop pollution the mine might as well close. Waste and pollution in a production process can be a sign that the process is not as efficient as it could be. Besides, it costs money to generate and dispose of waste. The respondents confirmed that the industries do have systems in place that monitor levels of pollution and contamination of the environment, yet these are not 100% effective and are implemented only to comply with the set government regulations in the industries. This is supported by Morrow and Rondinelli (2002:161), who state that although business enterprises in most industrialised countries have adopted environmental protection practices required by government agencies since the early 1970s, these regulations largely focus on control of water and air emissions and waste disposal. The introduction of green manufacturing will necessitate the elimination of current monitoring systems in favour of more holistic ones. Hence, *proper use of monitoring and control systems* remains a challenge.

Lack of clear policy and legislative direction

Government regulation usually requires business enterprises to reduce or eliminate their toxic air and water pollution by using technologies that control or clean emissions at the 'end of the pipe' (Morrow & Rondinelli 2002:161). The respondents recommend the revision of current policies and legislations to be stricter and more severe where there is no compliance; that is, the penalty fee for non-compliance must be higher than the cost of initiating GrSCM. The respondents compared the green issue with safety and feel that environmental protection is not emphasised enough. The respondents and the literature agree that unless GrSCM is effectively implemented and properly enforced, the solid framework for governance remains a mere intention (Department of Environmental Affairs and Tourism 2006:xix).

The respondents indicated that there is no clear policy direction when it comes to environmental issues from government. They believe that policies and regulation set by government are not explicit and do not address prevention to environmental risks, but the cure, which is to monitor and then correct. Furthermore, the respondents stated that the government does not see environmental risk as a priority, like safety for instance; they believe the government needs to make it a priority so that management can adapt and make it a policy within the industries. Hence, the *lack of clear policy and legislative direction* emerged as an important theme that respondents also raised as a challenge.

Cost of implementing green supply chain practices

> Extending the supply chain to include issues such as remanufacturing, recycling and refurbishing adds an additional level of complexity to existing supply chain design, in addition to a new set of potential strategic and operational issues, which, in turn, can increase costs, at least in the short term. (Linton *et al.* 2007:1079)

Luthra *et al.* (2011:239) concede that, usually, high cost is a big pressure in GrSCM as compared to conventional supply chain management (SCM). The respondents strongly supported this observation and they highlighted cost as a major constraint in the implementation of GrSCM. The respondents are convinced that should money be allocated, the implementation of GrSCM would be possible. However, the Department of Minerals and Energy (2005:27) also posit that GrSCM can cut the cost of materials purchasing and energy consumption, reduce the cost of waste treatment and discharge and avoid a fine in the case of environmental accidents.

In this regard, the respondents remarked that leaders of the supply chain department should balance low cost and innovation process whilst maintaining good environmental performance. The respondents acknowledged that the implementation of GrSCM requires capital initially, but it is a long-term investment. The respondents indicated that cost is a major challenge in the implementation of a green supply chain in the industries, as GrSCM requires new world-class technologies that will detect and control the waste generated. The greener you become, the more costly it is. Therefore, *costs* emerged as another critical theme.

Leadership and managing change

Beamon (1999:332) posits that the current state and trend of environmental degradation calls for a need to change manufacturing philosophy. Respondents are also convinced that the implementation of GrSCM requires a change in management strategy. They further elaborated by saying management should bring about this change. According to Tsoulfas and Pappis (2006:1594), the main environmental emphasis has been on the manufacturing phase and, to some degree, on the disposal phase. This revelation is confirmed by the respondents as they noted that workers in the plant play an important role in environmental protection. They believe that many workers are used to the way of doing things in a particular manner, as it has been done for several years and are therefore reluctant to change and try new ways of doing things. Hence, management needs to commit to environmental issues by enforcing a culture that promotes flexibility and encourages change amongst the staff. *Leadership and managing change* continues to hinder progress in many organisations.

Recommendations and conclusion

Hilson (2000:706) observed that challenges in the implementation of a green supply chain manifest themselves in the following ways:

- a lack of clear, continuous policies to support waste minimisation and cleaner production
- incomplete regulatory frameworks and uneven enforcement
- ignorance of the characteristics of industrialised production processes
- no clear understanding of the difference between compliance investments and cleaner technologies
- inefficient coordination amongst different government agencies at different levels.

Not surprisingly, Ravi and Shankar (2005:1016) believe that training and education are critical requirements for achieving successful implementation of GrSCM. These authors also suggest informal linkages and improved communication as helpful for organisations to adopt green practices, which requires capital. In this present article, lack of clear policies, legislative issues, technological constraints and inefficient coordination amongst different government agencies have been identified as major barriers to the implementation of a green supply chain in the South African manganese and phosphate mining industries. Although few mines have adopted processes of minimising environmental risk, the implementation of a green supply chain remains an option and it is not generally embraced because of the notion that it is costly. Government needs to play an expanded role in enforcing legislation and set harsh penalties for non-compliance by the mines. Before it uses the 'stick' approach, as it were, government needs to support the manganese and phosphate mines more with an appreciation of the need to implement GrSCM. At a policy level, it is recommended that the adoption of cleaner production practices become standard for all manganese and phosphate mining houses in South Africa.

At a managerial level, top management in the various mines need to take the initiative of increasing awareness amongst the supply chain stakeholders. This can be achieved by holding environmental awareness seminars for suppliers and vendors, undertaking programmes to educate about the benefits and relevance of green supply chain initiatives, providing platforms for information and offering rewards to stakeholders for pursuing the initiative. Owing to the fact that supply chain practitioners are custodians of the supply chain process, policies must be introduced where sourcing strategies are only approved if green issues are considered. Furthermore, management needs to develop a GrSCM adoption strategy which enables the mines to handle, minimise and anticipate problems with waste. The critical elements of this strategy should cover:

- use of cleaner technologies
- training for stakeholders
- inclusion of environmental aspects in the sourcing strategy
- redesigning of plants to better accommodate wastes
- funding for environmental awareness and change management
- collaboration between stakeholders (internal and external) to encourage knowledge sharing.

It is apparent that the mines have limited knowledge of cleaner technologies and cleaner production practices. Firstly, given the fact that the study sheds light on the challenges of the implementation of GrSCM in the managanese and phosphate mining industry, it is recommended that further research be undertaken to develop a green supply chain implementation model for the industry. Secondly, a study needs to be conducted on the perceptions and expectations of South African policymakers in this industry. Thirdly, a feasibility study needs to be undertaken on the link between the implementation of a green supply chain, cost saving and competitive advantage.

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Competing interests

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Authors' contributions

R.I.D.P. (Vaal University of Techonology) was a project supervisor, did the write up of the article, and the corresponding author, K.M. (Vaal University of Technology) reviewed the literature and conducted interviews.

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