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ORIGINAL PAPER

Effects of Sustainable Business Networks on the Environmentally Sound Management of Chemicals in Zimbabwe

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Abstract
Despite the formulation of policy frameworks and awareness on hazardous chemical management, practical implementation at organisational level remains a challenge in Zimbabwe. Participation in inter-organisational networks has been shown to have a catalytic role in some contexts. Sustainable business networks such as the Business Council for Sustainable Development Zimbabwe (BCSDZ) have undertaken programmes to promote safe chemical management and chemical leasing. This research paper assesses the effects of sustainable business networks on circular economy (CE) through implementation of safe chemical management and chemical leasing programmes in Zimbabwe. The research paper is based on forty (40) companies drawn from the industrial, manufacturing and mining sectors in Zimbabwe. A total of 50% of the companies assessed were selected because they participated in the safe chemical management programme called responsible production toolkit training and chemical leasing training during the period of 2018 to 2023, whilst the other 50% selected were not participants in any chemical management initiative to provide a comparison group to enable causal inferences. The study employed direct observation of chemical management practices, interviews with key informants and content analysis. Barriers and challenges identified included high chemical intensity, higher proportion of chemical accidents, inadequate provision of personal protective equipment (PPE), lack of clear policies on chemical management, lack of adequate technical capacity on chemical management, use of foreign languages in some material safety data sheets (MSDS), incompatible chemical storage practices, lack of proper labelling of chemicals, inadequate implementation of chemical compatibility charts and inadequate documentation of successful case studies. Implementation of chemical risk assessment increased from 20 to 70% due to network participation. Chemical inventorying implementation increased from 15 to 50% amongst firms that participated in safe chemical management programmes. Chemical labelling practices increased from 55 to 85% due to increased participation in network-induced chemical management programmes. Chemical leasing implementation remained largely unchanged even with access to training. We conclude that network participation enhanced chemical management practices due to the implementation of the responsible production toolkit. However, the impact of network participation on adoption of chemical leasing is low in Zimbabwe due to external contextual factors such as policy, perception, legal and financial barriers.

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Introduction

Towards Safe Chemical Management

In recent years, the global consumption of chemicals has been on an unprecedented increase in many developing and transition countries [1]. The multi-purpose nature of chemicals makes them to be on very high demand for use in different sectors of the economy. However, their impacts on human health, environment and society are unprecedented and dangerous if not effectively managed [2]. Currently, chemicals are needed for multifaceted industrial, domestic, manufacturing, mining, medicinal and other uses. It is essential that environmentally sound management of chemicals is promoted at all stages of the value chain. According to the Global Chemicals Outlook (GCO), the value chain of chemicals, also referred to as the life cycle of chemicals, consists of five stages—extraction of raw materials, chemical manufacture, chemical use downstream manufacture, products manufacture and products use and reuse [1]. These stages require effective controls in order to prevent adverse effects on the environment, human health and safety. Immune effects of chemicals on human systems have been previously cited and it has been confirmed that chemical exposure can reduce the ability of humans to fight off diseases [3]. Toxicological effects of chemicals in Zimbabwe have been confirmed, through a study of eight hospitals [2]. The careful management of chemicals is essential in the quest to attain a circular economy (CE) as chemicals have an effect on natural systems due to their anthropogenic effects.

In Zimbabwe, the usage of chemicals has been witnessed in sectors such as agriculture, leather, food, beverages, pharmaceuticals, dairy, mining and construction. The usage of chemicals has been associated with exposure to chemical hazards [1, 4]. This is especially pronounced in the small-scale mining sectors which contribute to gold production of the country. Furthermore, fertiliser and chemical processing companies have added to the burgeoning chemical management crisis. If improperly managed, chemicals may also result in deliberate self-poisoning (DSP) [2].

A circular economy facilitates reduction of environmental impacts of economic activities whilst enhancing economic goals [5]. Pollution prevention can facilitate waste minimisation in our society [6]. Due to the inherent risk of chemicals, effective regulations, policy, technology and novel approaches are necessary in order to attain environmentally sound management of chemicals. One of the ways of dealing with chemical challenges is through sharing knowledge and capacity within sustainable business networks. Organisations require external support and knowledge from networks to enhance their capability and knowledge on chemical management. Sustainable business networks are recognised as effective agents for promoting sustainability in organisations [7].

Inter-organisational collaboration can be used as a means of disseminating pollution prevention, chemical management best practice, information and knowledge [8]. Most networks that focus on safe chemical management are borne out of the need to manage and mitigate the effects of chemicals on natural systems, human health and society. Without collaboration, it may be difficult for organisations to understand the effects of chemicals and to develop effective strategies for promoting their sustainable use. Stakeholder involvement is a key driver for disseminating green technologies in enterprises

[9, 10]. Network success is also determined by other factors beyond stakeholders who are working together to attain common goals [11, 12].

Network collaboration exerts pressures on organisations to behave in a certain manner due to coercive, mimetic, normative pressures as proposed by [13] in the elaboration of institutional isomorphism. With respect to safe chemical management, organisations can be brought to the same level of environmentally sound management of chemicals due to the isomorphic pressures.

Inter-organisational collaboration in Zimbabwe draws its early roots in the form of sustainable business networks which started in 1993 through the formation of the Business Council for Sustainable Development Zimbabwe (BCSDZ). This new form of collaboration for sustainable development came after the United Nations Conference on Environment and Development which had concluded in 1992 and had a positive impact on green manufacturing [14]. Ever since that time, the BCSDZ undertook a range of sustainability projects including specific actions meant to deal with burgeoning concerns towards increased chemical usage. Although networks are well proven to drive circular economy innovation in SMEs, there is very little research about them in Africa, as we discuss below their experiences in safe chemical management [15].

From the year 2018 to 2023, the BCSDZ undertook a number of specific chemical management initiatives ranging from training, capacity building and audits. These activities were focused on responsible production toolkit as well as chemical leasing. The responsible production toolkit was developed by the United Nations Environment Programme (UNEP), Accountability, International Chemical Councils Association (ICCA), BIPRO and International Council on Mining and Metals [4]. Its dissemination has been through different stakeholders such as National Cleaner Production Centres, industry associations, networks and organisations on their own. However, there has not been any study to assess how the responsible production toolkit on safe chemical management is being disseminated through networks.

Sustainable business networks (SBNs) such as the Business Council for Sustainable Development Zimbabwe (BCSDZ) have undertaken training and capacity building programmes to enhance the uptake of safe chemical management. Through capacity building, technical assistance and awareness raising, SMEs can improve their chemical management practices. However, the effectiveness of such programmes in the context of collaboration has not been independently assessed. It is not yet clear whether the collaboration amongst the members is effective in facilitating enterprise-wide chemical management improvements. Isolating network effects on the long-term chemical management improvements is a daunting endeavour given the multi-actor context and the contribution of other stakeholders such as those from regulation, market, technology and social dimensions. There are gaps in literature regarding the contribution of the BCSDZ and other like-minded networks to facilitate safe chemical management and circular economy practices. Great care needs to be taken to avoid exaggerating the attribution of network activities to enhanced CE performance. Specific indicators have been identified as appropriate measures of progress. Networks can be agents of prosperity and transition towards sustainable development [16].

This paper assesses safe chemical management programmes which were implemented through the BCSDZ network in different sectors between 2018 and 2023. Specific programmes Responsible Production Toolkit—A Framework for Chemical Accident Prevention and Chemical Leasing programme activities are assessed in the study, in the context of network dissemination. The effects of training and capacity

building delivered through network participation to improve management chemical hazards are analysed.

Although most registered companies in Zimbabwe have policies to handle, manage, dispose, store and transport hazardous chemicals, there is a growing informal sector which is chemical intensive. In recent years in Zimbabwe, there has been a spurt in the emergence of businesses operating as home industries, cottage industries and backyard industries which are handling high volumes of reactive hazardous chemicals. Some of these small businesses are controlled by single owners and thereby not interested in chemical management practices [17]. This group of companies is not participants of any sustainable business networks due to their propensity to dodge regulatory pressure and public scrutiny. It is envisaged that full implementation of legislation and the promotion of safe chemical management in these industrial sectors can greatly improve the capabilities of these firms to manage their chemical substances.

Extending network participation to more SMEs can improve chemical management practices and ultimately facilitate CE transition. Circular economy transition enables environmental and economic benefits and thereby fosters sustainable development [18, 19]. Some SMEs have limited capacity for environmentally sound management of chemical substances. Earlier studies of SMEs in Zimbabwe confirm that they are not particularly concerned about Occupational Safety and Health (OSH) practices and are generally owner-driven [17]. For most SMEs, participation in sustainable business networks is a secondary issue as compared to business survival. This often results in a missed opportunity for innovating towards sustainable chemical management. Without tacit knowledge, it is difficult for organisations to attain sustainable development [20]. Network participation is seen as a window of hope in fostering CE through safe chemical management.

This paper presents the opportunities and challenges associated with hazardous chemical management in Zimbabwe and the effects of network participation on selected chemical management practices. Barriers faced in promoting sustainable innovations are clarified by [21] in the context of industrial symbiosis. Previously, technical assistance activities have been promulgated through UNIDO, UNEP, Environmental Management Agency (EMA), Business Council for Sustainable Development Zimbabwe (BCSDZ), independent consultants and non-governmental organisations (NGOs); but there still remains gaps in the full implementation of chemical management practices at the shop-floor level. The effectiveness of network collaborative activities on chemical management has not been adequately researched in Zimbabwe.

Legal Framework for Hazardous Chemical Management in Zimbabwe

Most of the legal and policy instruments in Zimbabwe are complimentary to its international obligations from Multilateral Environmental Agreements (MEAs). Zimbabwe ratified Multilateral Environmental Agreements (MEAs) governing environmentally sound management of chemicals such as the Basel Convention on the Transboundary Movement of Chemicals and their waste, the Rotterdam Convention, and the Minamata Convention. These MEAs form the basis of formulating national legal and policy frameworks on chemical management. Full implementation of such commitments and mainstreaming into national legislation requires improvement. In addition, sustainable business networks promoting these legal requirements have not been adequately researched to assess their effectiveness in transforming chemical management practices.

Globally, it has been recognized that policy and legislation are essential components of promulgating behaviour change in different countries. Policy is seen as a response to environmental deviance. Hazardous chemical management requires a robust policy framework to guide industry and other stakeholders that use chemical substances. In this regard, Zimbabwe has formulated various policies and regulations to control deviant behaviour and ensure sound environmental management of chemical substances [22–25].

Policy instruments are therefore crafted by governments to guide the conduct of individuals, organisations and stakeholders alike. Chemical management in Zimbabwe is regulated by several laws which govern the conduct of organisations and individuals [24, 25]. These Acts and Statutory Instruments present guiding principles for those in the chemicals value chain. Sustainable business networks have a key role in raising awareness and technical capacity on the legal and policy requirements.

The Constitution of Zimbabwe Amendment Number 20 of 2013 recognises environmental rights in Sect. 73. Furthermore, the Environmental Management Act 20:27 provides a guiding framework on environmental issues, including the management of chemicals. This regulation requires organisations to apply for hazardous chemical permits. The permits apply to the production, distribution, transport, storage, recycling and handling of hazardous chemicals and materials. The licence or permit is issued by the Environmental Management Agency (EMA) and renewed on an annual basis.

Several statutory instruments have been established to ensure that environmental sound management of chemicals is adhered to. The Environmental Management (Hazardous Waste Management) Regulations S.I. 10 of 2007 and Hazardous Substances Control Regulation S.I. 268 of 2018 are more specific regulations on the critical issues governing chemical management in Zimbabwe [25]. These regulations stipulate that no person is allowed to generate, store, sell, transport, use, recycle, discharge or dispose of hazardous waste to the environment except under licence. The regulations also further stipulate the need for all chemicals being transported to be clearly labelled and to have a consignment note. In cases of accidental spillage, it is the duty of the party that causes the spillage to carry out clean-up activities. The storage, handling and transport of incompatible chemicals are strictly prohibited. Other key regulations governing chemical management in Zimbabwe include the Factories and Works Act 14:08 of 1976 and the Rhodesia Government Notice (RGN) 263, which require the provision of personal protective equipment to employees who are exposed to chemical substances and also regulate dangerous substances and processes [22].

Despite the existence of legal instruments governing hazardous chemical management in Zimbabwe, there are challenges in the actual practice on the shop-floor and there is need to strengthen implementation of hazardous chemical legislation [17]. Networks of organisations present solutions that can help to alleviate some of the challenges being faced in implementing legal requirements. Participation in networks can cause progressive influences on organisations to adopt practices which are environmentally sound [8, 26]. Several empirical studies outside Africa demonstrate the effect of network participation on improved sustainability performance within organisations [27, 28].

Role of Networks in Promoting Safe Chemical Management

Adoption of sustainability practices such as safe chemical management practices requires specialised knowledge within organisations [20]. This knowledge may not be inherent within the idiosyncratic organisations. Becoming a member of a sustainable business network can

contribute to improved awareness on the toxicology of chemicals. Empirical studies in different country contexts confirm the effect of network participation on the ability of organisations to implement green innovations [14, 16, 26, 27, 29–33].

Networks have key abilities to provide capacity building, training, awareness and promotion of novel strategies effective in dealing with chemical hazards. Despite their growth, networks also face barriers and challenges such as financial, technical, differences in perception, conflicts and culture amongst other obstacles [33, 34]. Networks thrive to attain measurable outcomes within the confines of their chosen thematic focus and their governance is a determinant of their success or failure [35]. Apart from collaboration, networks also may have divergent and opposing views of specific issues of concern [36].

New business models, such as chemical leasing, have been popularised and accelerated by sustainable business networks: National Cleaner Production Centres (NCPCs) *(which have evolved beyond merely looking at cleaner production assessments)* [37] and the Global RECP-Net which was formed to strengthen collaboration on RECP. Material efficiency models are essential in reducing cost and environmental impacts [38]. These business models can be effectively applied to chemical management through dematerialising chemical substances and shifting towards the functions and services offered by the chemicals. Organisational innovation in the area of chemical management can be influenced by a number of factors which are context-specific. These factors may include policy, regulation, financing, technology and external intermediary institutions such as sustainable business networks. Chemical leasing is a subset of safe chemical management. It is a performance-based business model to implement safe management of chemicals. It was selected because it is a new business model in Zimbabwe and there has been no independent study to assess whether it is making an impact or not. Ultimately, the use of business models such as chemical leasing is envisaged to reduce the high chemical intensity in Zimbabwean industry. This research looks at both chemical leasing and safe chemical management as there were multiple interventions during the period of 2018–2023 in the BCSDZ, hence the need to assess them all.

This research specifically assesses the effects of network participation on safe chemical management practices of organisations. In particular, the research assesses the following questions:

i. What is the role of sustainable business networks in facilitating safe chemical management in SMEs in Zimbabwe?
ii. What are the legal and policy frameworks enabling safe chemical management in Zimbabwe?
iii. What are the effects of network participation on the eventual chemical management practices in Zimbabwe?
iv. What are the effects of specific programmes—Responsible Production Toolkit—A Framework for Chemical Accident Prevention as well as Chemical Leasing Programmes.
v. What barriers and challenges affect network participation on safe chemical management?

Materials and Methods

The research is based on the safe chemical management projects undertaken by BCSDZ between 2018 and 2023, namely Responsible Production Toolkit—A Framework for Chemical Accident Prevention as well as Chemical Leasing. Data collection was

undertaken using qualitative and quantitative methods. Key informant interviews, observations and content analysis of corporate documents drawn from members of the Business Council for Sustainable Development Zimbabwe and non-members. In order to ensure that the observations were systematic, a checklist was used. Evaluation of training records and secondary data related to chemical management practices was carried out in order to further understand the effects of network on safe chemical management. A total of 3 physical training and capacity building networking events were attended by the researcher and included chemical leasing, responsible production and industrial hazardous waste training.

Content analysis of 20 network member companies was undertaken in order to identify trends in their chemical management practices. This was in order to ensure that there was a group of organisations from industrial sectors which were involved in the usage of chemicals. The criteria for selecting organisations for the safe chemical management study included the following:

a) Organisations which were in industrial, manufacturing and mining sector
b) Organisations which used chemicals in any part of their production processes
c) Organisation with interest and willingness to participate
d) Organisations which were members of the Business Council for Sustainable Development Zimbabwe (BCSDZ)
e) Organisations based in Harare, the capital city of Zimbabwe.

A comparative group of 20 organisations with organisations which did not belong to the Business Council for Sustainable Development Zimbabwe (BCSDZ) was selected to assess its chemical inventorying, chemical risk assessment practices and chemical labelling practices. The criteria for selecting this group were based on the following factors.

a) Organisations which were in industrial, manufacturing and mining sector.
b) Organisations which used chemicals in any part of their production processes.
c) Organisation with interest and willingness to participate.
d) Organisations which were not members of the Business Council for Sustainable Development Zimbabwe (BCSDZ) and did not belong to any sustainable business network.
e) Organisations based in Harare, the capital city of Zimbabwe.

The comparative group did not participate in chemical management training activities such as the responsible production toolkit or chemical leasing training. Their chemical management performance was also assessed qualitatively and document review was undertaken in the same method and approach as compared to the group of organisations in the network. In order to ensure consistency in the case studies, the interview questions were kept consistent. Yin [28] elaborates on how to effectively evaluate case studies majoring on depth rather than breadth.

Information was analysed using qualitative analysis methods and common thematic patterns were established (chemical risk assessment, chemical inventorying and chemical labelling) in order to provide a framework for analysing data. Data was analysed using descriptive statistics. In order to ensure data validity and reliability, the research implemented triangulation of data and triangulation of sources. This process was also meant to prevent any form of biases in the information provided about chemical management.

Existing chemical management practices within organisations were also assessed using the best-practice requirements stipulated by the responsible production toolkit.

Results

Effects of Sustainable Business Networks and Chemical Management in Zimbabwe

Participation in sustainable business networks demonstrated improvements in chemical risk assessment, chemical inventorying and chemical labelling as shown in Fig. 1. Detailed analysis of the different dimensions of chemical management is further explained in the "Effects on Chemical Risk Assessments" section and "Effects of Networks on Chemical Inventorying Practices" section, respectively.

Effects on Chemical Risk Assessments

Before the implementation of the safe chemical management programmes offered by the network, 50% of the firms involved in networks were not carrying out chemical risk assessment despite the hazards that were posed by the usage of chemicals in their production processes. Some 30% of firms belonging to networks had integrated chemical risk assessment to some extent through the generic risk assessment process that was implemented at their various companies. Although partially implemented, the risk assessment did not fully address the demands of chemical hazards. This means that for those companies, there was no exclusive risk assessment focused on chemicals, but rather chemicals were considered as part of the general risk profile of the organisation where applicable. A proportion of 20% of network members was carrying out chemical full-risk assessments. However, this

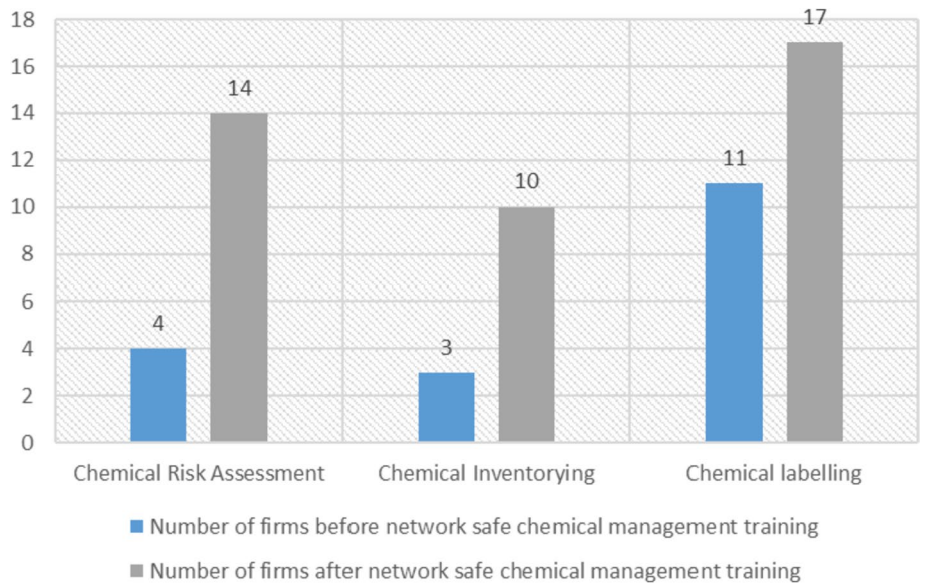

Fig. 1 Effects of network participation on selected chemical management practices in Zimbabwean industry

proportion of organisations undertaking full chemical risk assessment increased to 70% due to participation in safe chemical management training facilitated by the BCSDZ in the form of responsible production training.

Effects of Networks on Chemical Inventorying Practices

Through the training received during the responsible production toolkit, we noted that only 15% were implementing chemical inventorying practices, 45% were partial chemical inventorying and 40% were not implementing chemical inventorying. Despite some of the organisations implementing international environmental standards; there were no specific tools tailor-made to the quantification of hazardous chemicals and their waste. In some cases, there was partial inventorying and also the use of estimates in characterising chemical quantities. Due to participation in safe chemical management programmes, the number of firms undertaking chemical inventorying increased to 50%.

Figure 1 shows the effects of network participation on improved chemical management practices of firms. It can be observed that chemical labelling, inventorying and chemical risk assessment improved after implementation of network-induced chemical management programmes.

Before participation in safe chemical management programmes promoted by the Business Council for Sustainable Development Zimbabwe, within the sample of companies that participated in the Responsible Production—A Framework Safe Chemicals Management training, the number of companies practicing effective chemical labelling was 55% and those not undertaking effective chemical labelling were 45%. Due to the network activities and capacity building, uptake of chemical labelling increased to 85% and those not undertaking safe chemical management reduced to 15%. The programme of training organisations on safe chemical management managed to enhance uptake of labelling practices in order to provide a high level of awareness on chemical toxicity. Network participation improved chemical labelling practices.

Following technical capacity building and training offered by the Business Council for Sustainable Development Zimbabwe (BCSDZ), there was an improvement in the chemical management practices at the company level. Some of the improvements included a higher level of awareness, improved chemical labelling, development of chemical compatibility charts, documentation of standard operating procedures, installation of emergency equipment and provision of personal protective equipment (PPE). The adoption of environmentally sound management of chemicals varied widely from company to company. Participating organisations cited the contribution from the sustainable business network as playing a significant effect in their chemical management practices.

Sustainable business networks showed ability to enable attainment of safe chemical management and a circular economy. A model of collaboration on safe chemical management was provided by the Business Council for Sustainable Development Zimbabwe. Training courses on safe chemical management were undertaken, bringing together organisations from different industrial sectors. The training covered aspects related to chemical production, chemical handling, chemical disposal, and other aspects of chemical disposal.

Without the technical knowledge from the network, the level of awareness was low in the participating organisations. The network participation enabled higher adoption of chemical risk assessment, chemical inventorying and adoption of the Globally Harmonised System on the labelling and classification of chemicals.

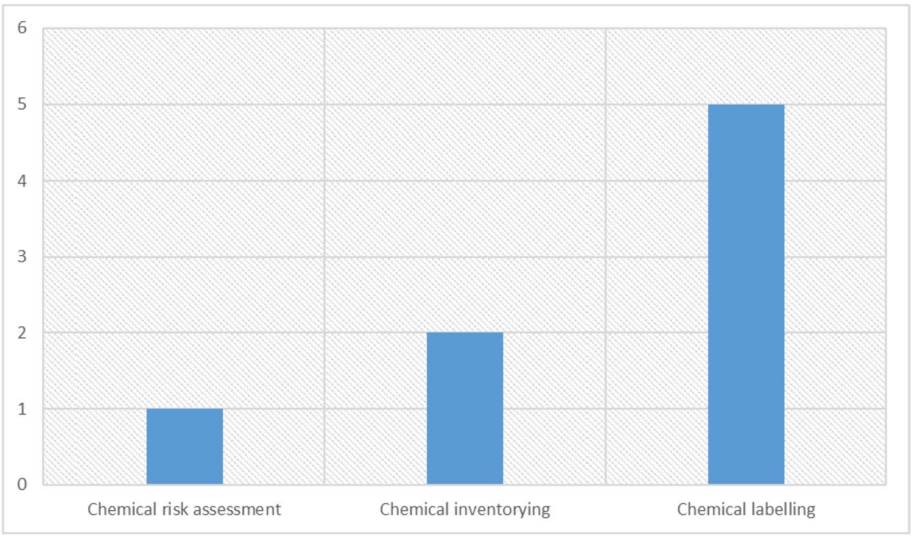

Fig. 2 Selected chemical management practices in Zimbabwean industry for organisations not participating in sustainable business networks

In comparison to the group of firms which were members of the Business Council for Sustainable Development, Fig. 2 shows results from firms which were operating idiosyncratically without network participation. Their chemical management practices were lower than those of firms involved in training and capacity building of the Business Council for Sustainable Development Zimbabwe. Specifically, the chemical risk assessment was undertaken by 5% of the organisations, chemical inventorying was undertaken by 10% and chemical labelling was undertaken by 25% of the organisations. Within the control group, 95% of organisations were not undertaking chemical risk assessments, 90% were not undertaking chemical inventorying and 75% were not undertaking effective chemical labelling. This demonstrates that the network participation had a significant effect on the capacities of organisations to implement safe chemical management practices.

However, it should be noted that the results show that even without network participation, chemical management practices are possible. Other factors which may contribute to anecdotal chemical management capabilities include government pressures, market pressures and international standards. The group of organisations which did not participate in networks still undertook safe chemical management at a lower level.

Even with a lower chemical management footprint, the idiosyncratic organisations still have some form of chemical management. This could be due to other activities such as group requirements, regulatory pressures and awareness of employees. However, this capacity can be fast-tracked through network participation. These results show that although inherent capabilities to manage chemicals exist within organisations, these capabilities can be increased and enhanced by network participation and collaboration. The existence of industrial clusters in the country should be a key driver towards the promotion of safe chemical management through the various cluster meetings and legal compliance audits including chemical management audits.

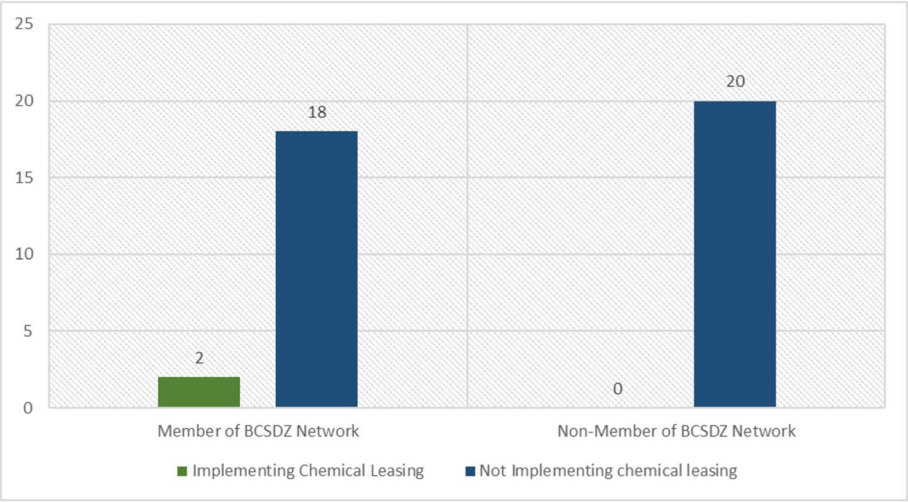

Fig. 3 Effects of collaboration on adoption chemical leasing business models

The research notes that chemical service business models are still unpopular in Zimbabwe. Organisations are also not willing to take risks with unfamiliar models for chemical management. However, through networks of the BCSDZ, organisations started to participate in training and capacity building related to chemical management. Chemical leasing business model should be fully explored, due to its potential to reduce environmental impact and save costs. Chemical leasing pays for the services of chemicals and not for their quantities. In the organisations that were assessed, the implementation of chemical leasing was uncommon. The organisations were mostly concerned about purchasing chemicals rather than paying for their services.

Figure 3 demonstrates that the number of organisations not implementing chemical leasing is high. A total of 18 out of the 20 selected companies failed to implement chemical leasing. Even after receiving training, there was no significant improvement in chemical leasing implementation. The situation is even dire in organisations that are non-members of the sustainable business network, as 20 out of the 20 selected organisations did not implement chemical leasing at all. There may be an urgent need to address the barriers associated with its implementation as well as to facilitate policy support and incentives towards its implementation in Zimbabwe.

Challenges to Implementing Environmentally Sound Management of Chemicals

The challenges to successful implementation of environmentally sound management of chemicals in Zimbabwean industry are multi-faceted. This research identified these challenges as attributable to weak network development, financial barriers, limited collaboration, policy and organisational factors. This paper shows that some companies have not yet implemented chemical management systems, but those which collaborate show higher chemical management capabilities, especially related to the chemical risk assessment and chemical risk inventorying. These findings confirm earlier research by [15] that collaboration enables SMEs to overcome barriers related to attaining sustainable development. Although barriers are common amongst the two different groups of companies, network

members had a better capability to overcome barriers in comparison to idiosyncratic firm, due to the availability of information, technology and knowledge in networks. After participation in networks, the barriers were reduced in collaborative organisations.

Lack of Formal Environmental Management Systems

Lack of environmental management systems such as ISO 14001 in selected industries reduced their potential for chemical accident prevention. Some companies interviewed considered ISO 14001 and other environmental standards to be cumbersome and expensive and hence failed to establish an effective way of identifying chemical hazards in the workplace. Standards allow identification of environmental aspects such as chemical usage.

Low Priority of Chemical Management

Low prioritisation of environmental health and safety functions in selected companies also reduced the potential for safe chemical management. Whilst we note that some enterprises in Zimbabwe have incorporated environmental management into the corporate structure, there is still evidence that in some companies, it is still non-existent and there is no clear delegation of duties related to hazardous chemical management at the corporate level. This situation was very prevalent in SMEs and organisations of a smaller scale due to a higher level of informality.

Poor Governance of Chemicals and Sustainability-Related Issues

Governance structures and the delegation of responsibilities at the corporate level were observed to be a challenge in enabling chemical safety. Another key challenge identified was the low awareness on the nature and properties of chemicals. Furthermore, low technical capacity on principles of hazardous chemical management was another drawback that should be addressed through sectoral and thematic projects addressing technical capacity in chemical management and continued capacity building. This barrier was most common in organisations without network collaboration.

Limited Financial Resources

Limited financial resources to institute hazardous chemical management programmes were also cited as a challenge to achieving environmentally sound management of chemicals. Very few if any financial institutions in Zimbabwe offer financing on chemical management. It is therefore important to ensure that funding schemes are established that encourage efficient process automation and reduce chemical spillages, thereby reducing the amount of time the employees are exposed to the chemical substances. Collaboration with banks and financial institutions could be a key strategy to scale up safe chemical management.

Use of Foreign Languages in Communicating Chemical Hazards

Language barriers affected the scaling up of safe chemical management in enterprises. Due to the fact that some of the chemical substances were being imported from other countries, there emerged an issue of the use of foreign languages on some chemical labels and MSDSs. Lack of understanding of the chemical composition and the emergency

preparedness requirements specified by an MSDS posed further problems due to the failure to take precautionary measures. In cases where the MSDSs exist, there were also issues regarding limited understanding and interpretation of MSDSs.

Limited Infrastructure

Inadequate infrastructure for chemical management was regarded as a major drawback towards safe chemical management. The paper notes that some sites have inadequate level of preparedness to chemical emergency situations, e.g. malfunctioning emergency showers, lack of bund walls for temporary storage of chemicals, inadequately ventilated chemical storage facilities and limited automation of the chemical dispensing and handling process.

Lack of Adequate Personal Protective Equipment (PPE)

The other challenge that affected the scaling up of hazardous chemical management includes the access to personal protective equipment (PPE) which was limited in some industries. Personal protective equipment such as work suits, rubber gloves, goggles, safety shoes, leather aprons and other relevant PPE is still not fully provided and utilised in selected industries. Companies should ensure that their employees are well protected. Where PPE is provided, training on proper usage and supervision is required.

Low Implementation of the Globally Harmonised System on the Labelling and Classification of Chemicals (GHS)

The Global Harmonised System on Chemical Labelling and Classification (GHS) is not yet fully implemented at the shop-floor in Zimbabwe and this is a critical challenge in forwarding the agenda of environmentally sound management of hazardous chemicals.

Through this research paper and practical implementation with SMEs, we note that in order to inculcate an environmental sound management of chemicals philosophy, there is a need to make sure that key documentation including standard operational procedures (SOPs) Material safety data sheets (MSDS) is also translated to local languages where practicable. Earlier studies by [17] confirm that some SMEs are not effective in implementing procedures for occupational safety and health.

Opportunities for Implementing Environmentally Sound Management of Chemicals

Existence of a Legal and Policy Framework

There were several opportunities identified in the research, for the environmentally sound management chemicals. Firstly, a clear legal framework, *which already exists*, was cited as having the potential to yield significant benefits at the shop-floor level if fully implemented and enforced. Proper enforcement of chemical management practices is an urgent requirement. The existence of vast information and literature regarding the safe management of chemicals was cited as a potential means for scaling up safe chemical management. The development of sustainable business networks such as the Business Council for Sustainable Development Zimbabwe was cited as an effective knowledge management system and information dissemination channel to all enterprises. Scaling up the network participation was identified as a platform for there can be widespread change in the current practices of chemical management.

Existence of Institutional Frameworks and Stakeholder Networks

An institutional framework and a variety of stakeholder networks were seen as providing vast opportunities for full implementation of environmentally sound management of chemicals. There are well-established stakeholders in Zimbabwe dealing with chemical management issues including the National Cleaner Production Centre (NCPC), Business Council for Sustainable Development Zimbabwe, industrial clusters and independent service providers such as consultants. However, some key informants stated that these stakeholder networks were not being fully utilised to their fullest potential. Collaboration amongst the stakeholders was cited as a necessary step required to step up safe chemical management.

The Zimbabwe National Cleaner Production Centre, through its cleaner production programme, implemented cleaner production projects in various economic sectors such as cable manufacturing, battery manufacturing, electroplating, leather tanning, foundries, chemical processing, plastic manufacturing and pharmaceuticals amongst other economic sectors. Some of the identified cleaner production options were related to chemical safety. Various options have been suggested but most were hindered by financial capability to invest and maintain the options. Up-scaling these measures still requires improvements. This opportunity was underutilised and greater effort was noted as essential to scale up safe chemical management in Zimbabwe.

The Business Council for Sustainable Development Zimbabwe (BCSDZ),[1] which is a leading network for sustainability in Zimbabwe, brought together various members from the industry, government and research in the form of a Public Private Partnerships such as the Green Industry Initiative. The initiative promoted safe chemical management, energy efficiency, renewable energy, efficient water utilisation and waste management. Due to lack of funding, the opportunity was not fully harnessed. However, further opportunities exist through information dissemination on hazardous waste management. The BCSDZ has implemented initiatives such as the Green Industry Initiative which has a component of safe chemical management.

Availability of Consultants and Technical Expertise on Chemical Management

Consultants were also cited as an opportunity for networks to mainstream safe chemical management practices. These consultants were members of the industry associations and business networks. Independent service providers have been involved in the process of mainstreaming environmentally sound management of chemicals throughout the value chain. Their role and opportunity for providing technical information in chemical management were identified as a key catalyst to chemical management transformation in Zimbabwe. These consultants have carried out training courses in transport, medical laboratory, manufacturing, mining and construction based on the responsible production toolkit framework for chemical accident prevention in SMEs[2]. The study notes complementarities between the activities of the sustainable business networks and consulting organisations.

[1] BCSDZ is a Regional Networking Partner of the World Business Council for Sustainable Development (WBCSD) and has been implementing sustainability programmes for more than 30 years in Zimbabwe. The BCSDZ is also an institutional member of the African Roundtable on Sustainable Consumption and Production (ARSCP).

[2] The responsible production toolkit is a training package which has information on how SMEs can effectively manage hazardous chemicals.

Discussion

Chemical hazard risk assessment framework requires improvement and enforcement in Zimbabwe. Some organisations were not yet fully implementing the process of hazard identification, risk assessment and determination of controls. In cases where risk assessment was done, it anecdotally addresses issues of chemical risk assessment. This resulted in tasks that involved chemical handling being carried out at times without proper hazard characterisation. There is a need for more capacity building of SMEs in safer production processes. Networks should emphasise chemical risk assessments in their capacity building programmes.

Without network participation, there was low adoption of chemical inventorying amongst small to medium sized enterprises handling chemicals. We noted that about 50% SMEs in this study were not carrying out chemical inventorying activities. This becomes a challenge when there is a need to account for chemicals or when there is a need to characterise the amount of chemical waste or to determine efficiency of the production process. However, network participation improved chemical inventorying practices. Collaboration activities of the Business Council for Sustainable Development Zimbabwe resulted in an improvement in the inventorying and chemical management practices in Zimbabwe.

The provision and usage of personal protective equipment still need to be improved in most organisations. Some organisations are still facing challenges in providing adequate PPE for employees handling hazardous chemicals in their production process and this increases the level of exposure to the hazardous chemicals. In some cases, the wrong PPE was being prescribed, for example where there is exposure to solvents and volatile organic compounds, we noted the prescription of dust masks which were not very effective against chemical vapours and gases. Personal protective equipment for chemical management should be suitable for the task to be undertaken.

Stakeholder engagement and community participation in issues of chemical management are still low. Despite the requirement by the responsible production framework to engage stakeholders in chemical management, most industries rather prefer to implement chemical management programmes in isolation and mainly centralised at the organisational level. This could be interpreted as being caused by fear of being scrutinised or publicised by members of the public with respect to chemical management practices.

Most organisations are concerned about their public relations and standing in society, so they would rather operate in a discreet manner than in the proximity of the public eye. It can be noted that in some cases, communities were left out and were mainly informed after major events such as spillages occurred. It is essential to strengthen legal and policy frameworks on the need to inform the community about the imminent hazards associated with the usage of particular chemicals.

Limited technical capacity to implement chemical management and hazardous waste management programmes is a key challenge in Zimbabwe, but network participation improves the situation. The research paper noted that several SMEs lack in terms of organisational structure and responsibility for personnel that have responsibility for chemical management. Although some had appointed Safety, Health, Environmental and Quality (SHEQ) Officers and Managers, the technical capacity on the fundamentals of chemical management amongst these employees requires significant improvement. The lack of consistency of training curricula of SHEQ Officers and Managers

resulted in their varying capacity to tackle chemical toxicology issues affecting their organisations.

Training programmes based on responsible production toolkit helped to improve the behaviour of firms. Employees handling hazardous substances can be brought to a level of compliance and attain a proactive culture in SMEs. Through observing production processes before and after the responsible production toolkit, there is a major difference in the practices by the employees and the culture in the organisation regarding the production, handling, transport, usage and disposal of hazardous chemicals. The training programmes on responsible production, which were enabled by network participation, facilitated an improvement in the chemical management practices of organisation. The research shows that sustainable business networks can facilitate transition towards safe chemical management and ultimately a circular economy. However, these findings may not be identical for new and emerging chemical business models.

However, training on chemical leasing through BCSDZ network failed to stimulate a surge in implementation of chemical leasing in Zimbabwe. Organisations in Zimbabwe are still not yet fully well-equipped and not adequately ready to implement chemical leasing. Presence of organisations in the chemical manufacturing sector presents paradoxes, where they prefer to sell chemicals rather than the services that they offer.

Other existing challenges noted during the research point to the need to strengthen knowledge on material safety data sheets (MSDS). Material safety data sheets should be available at the point of chemical usage and well understood by the chemical users. Whilst we note the ability of the companies that were analysed through this research in their ability to recognise the importance of material safety data sheets, there however seem to be challenges regarding their dissemination and use. Material safety data sheets serve a very important function in determining the properties, behaviour, emergency procedures and toxicity of chemicals. However, in selected Zimbabwean firms, not all chemicals were accompanied by their MSDSs, and at times where they exist, there is no adequate knowledge at the level of the chemical users. This is a key area requiring improvement. Some of the leading deficiencies related to a limited capability to interpret toxicological data such as lethal dose 50 and the non-observable effect concentration (NOEC). Chemical information and parameters of hazard character need to be further elucidated by sustainable business networks.

Storage of chemicals according to compatibility requires widespread adoption amongst Zimbabwean stakeholders. The research observed that most decisions to store chemicals were inspired by the availability of space alone rather than a consideration of chemical compatibility. Some of the SMEs interviewed during this research indicated their lack of knowledge regarding the formulation and usage of chemical compatibility charts and the storage of chemicals was at times indiscriminate of the chemical properties of the chemical. This is an area of concern which will require improvement through network training, enforcement of legal provisions and enhanced awareness. However, the process of ensuring that chemicals are stored according to compatibility rules was greatly improved through the adoption of the principles of the responsible production toolkit.

Cottage and backyard industries should be monitored to avoid environmental impact of chemicals in residential areas. Several SMEs operating in backyard or cottage industries did not have adequate capacity to manage their chemical processes hence the need to closely supervise their operations and implement regulatory requirements where necessary. Those actors who coordinate sustainable business networks should also include smaller

enterprises in their network activities to enable inclusivity and universal capacity development in safe chemical management.

With regards to chemical risk assessments, inventorying and labelling, barriers were related to technical assistance, whereas barriers related to chemical leasing were influenced by economic instruments and policy regimes at the national level. Despite individual actions directed at the company level on chemical leasing, in reality, adoption remained low.

Conclusions

In conclusion, we clearly note that collaboration amongst organisations results in improvement in safe chemical management in the industry. Through the network collaboration of the Business Council for Sustainable Development and adoption of the responsible production toolkit, chemical management performance of SMEs improved. However, the adoption of chemical leasing practices remained low, despite network participation. In order to prevent chemical accidents, there is a need to strengthen network collaborations amongst organisations, enforce legislation on chemicals, undertake factory inspections and follow up with industries, transporters, farmers and other chemical users. Stricter control of toxic chemical importation and transit at ports of entry should be instituted so as to eliminate extremely hazardous chemicals at the port of entry. Every stakeholder should be reminded that improper usage, handling and transport of chemicals can cause accidents, serious injuries, and death due to their fatal nature. All stakeholders therefore have to collaborate through networks and clusters of industries in raising awareness and providing a framework for safe chemical handling, usage and transport. We recommend the development and implementation of additional sustainable business networks basing their safe chemical management training on the responsible production framework to address some of the issues and challenges raised in this paper.

It can also be concluded that SMEs have the potential to implement hazardous chemical management programmes if they are given the adequate support through external stakeholders such as networks, capacity and financial assistance, and if appropriate, policy and legal mechanisms are fully enforced. The usage of PPE and its provision are key areas of improvement which SMEs should strive to implement even without supervision of the regulatory bodies. The achievement of good chemical management practices in Zimbabwe and other developing countries requires multi-stakeholder collaboration and Sustainable Business Networks in order to ensure that there is adequate implementation and buy-in amongst the stakeholders.

Chemical leasing dissemination through networks is still in its infancy and requires novel approaches to ensure that it is taken up at the enterprise level. Localisation and contextualisation of chemical management initiatives such as promoting material safety data sheets in local languages rather than foreign languages can yield better effects in safe chemical management in Zimbabwe.

i) What is the role of sustainable business networks in facilitating safe chemical management in SMEs in Zimbabwe?

Sustainable business networks play a significant role in raising awareness and providing technical assistance on safe chemical management. They also enable exchange of

information amongst organisations with respect to new business models of chemicals such as chemical leasing and dematerialised chemical management business models in organisations.

ii) What are the legal and policy frameworks enabling safe chemical management in Zimbabwe?

In Zimbabwe there are various regulations governing the implementation of safe chemical management. The most significant regulations include the Environmental Management Act 20:27 and Hazardous Substances Control Regulations Statutory Instrument 68 of 2018. Although these laws exist, we conclude that they need stronger implementation. There were also international standards such as ISO 14001:2015 Environmental Management Systems which acted as voluntary policy initiatives to promote safe chemical management. Very limited economic instruments such as taxes and subsidies exist to influence environmentally sound management of chemicals in Zimbabwe. The policy framework, voluntary standards and emerging *sermon type* and awareness instruments individually and collectively contributed to improved safe chemical management.

iii) What are the effects of network participation on the eventual chemical management practices in Zimbabwe?

The research concludes that network participation has a positive effect on safe chemical management practices such as chemical inventorying, chemical risk assessment and labelling of chemicals. Training of companies using the responsible production toolkit resulted in improved awareness amongst organisations. However, with regard to chemical leasing business models, there was no major difference between networked organisations and those not in networks. Network participation failed to evoke changes in service-based chemical management business models.

iv) What are the effects of specific programmes—Responsible Production Toolkit—A Framework for Chemical Accident Prevention as well as Chemical Leasing Programmes?

The responsible production toolkit had a positive effect on the chemical management practices of organisations which were members of the sustainable business network called the Business Council for Sustainable Development Zimbabwe (BCSDZ). However, there was no major improvement in both organisations belonging to networks and those that did not belong to networks, with regard to the adoption of chemical leasing business models. The research concludes that chemical leasing remains an elusive business model in Zimbabwe, with or without collaboration.

xxii) What barriers and challenges affect network participation on safe chemical management?

The barriers affecting network participation on safe chemical management included financial barriers and lack of technical capacity to implement environmentally sound management of chemicals. Furthermore, low prioritisation of safe chemical management, lack of effective structures to manage chemicals and language barriers posed challenges to the realisation of environmentally sound management of chemicals.

Declarations

Conflict of Interest The author declares no competing interests.

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