

OVERCOMING ENVIRONMENTAL CHALLENGES IN THE CEMENT MANUFACTURING SECTOR THROUGH CLEANER PRODUCTION. A CASE OF SINO COMPANY, ZIMBABWE

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Abstract

The paper investigated the extent to which Sino Zimbabwe Cement Company (SZCC) implemented Cleaner Production (CP) options to deal with high emissions and waste emanating from its operations. Research data was collected through questionnaires, interviews, direct observations and document analysis. Two sets of questionnaires were prepared targeting workers and the local community who were direct recipients of pollutants. Semi-structured interviews were conducted with key informants such as the Production Manager, the Human Resource Manager, the Finance Manager, Engineering Manager, the Health and Safety Officer and the District Environmental Management Agency Officer. Research findings revealed a reduction in dust emissions, volume of discharged effluent, residuals of oil contaminants and energy consumption. However, solid waste generation and its subsequent disposal remains a problem. Whilst adoption of CP can be viewed as a panacea to most environmental challenges faced by the organization, more investment is required towards elimination of some sources and cause of waste and emissions generation.

Key Words: Waste, Emissions, Cleaner production, Cement production, Legislation.

Introduction

The need to promote a vibrant and sustainable industrial sector has continued to be a major concern as the world positions itself towards a green economy in the post Rio+20 period. The apprehension is centered on the prospects that a sustainable industrial sector will enable present generation to safeguard the earth's life support system on which the welfare of the current and future generations depends (Griggs *et al.*, 2013). However, various industrial operations have been blamed for significant pollution to the detriment of the environment in most countries (Chenje, 2002; Egbon, 2004; Johnson, 2005; Marambanyika and Mutekwa, 2009). In response, international, regional and national policies and strategies were developed to improve the environmental

performance of industry. Cleaner production (CP) is one of the universally implemented strategies. It is also an integral component of international conventions and protocols such as the Kyoto Protocol and United Nations Framework Convention to Climate Change aimed at stabilization of greenhouse gases.

CP options developed by United Nations Environment Programme (UNEP) have been widely implemented across the globe. The primary goal of CP is pollution prevention by eliminating or reducing waste or emissions generating streams/processes in industrial operations while increasing the organization's profit margin. Studies carried out in Asia showed that CP resulted in a 50-70% reduction in emissions, water discharge and solid waste generation over a short payback period ranging from less than a year

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to 3 years (El-kholy, 2011). In Eastern Europe, CP projects reduced carbon dioxide emissions by 52,500 tonnes and sulphur dioxide emissions by 1,916 tonnes from 1998 to 1999 (Johnson, 2005). All these scenarios point towards a reduction in pollution levels, hence lessening of the impact of industrial operations on environmental integrity.

Projects and programmes related to CP have been initiated in Zimbabwe with the assistance of international organizations through information exchange and capacity building (UNEP 2004). In Kenya, the Chandaria Industries Limited in Nairobi through CP greatly improved the company's operations as evidenced by cost reduction, efficient resources use and improved environmental performance at large, thereby creating a significant contribution towards sustainable development by greening its operations (Johnson, 2005). However, it was noted that most of the CP programmes were short lived as they were donor-funded and even some projects in Zimbabwe were not spared (Mbowa, 2002; Chidavaenzi, 2011). This explains why over a decade, 2000-2011, Zimbabwe only had 42 companies which had adopted CP (Chidavaenzi, 2011). Therefore, some scholars argued that for CP initiatives to be successful, they must be locally initiated and implemented (Madzinga, 2000; King, 2003).

Successful CP implementation can be hindered by lack of top management commitment, lack of effective regulatory pressure, appropriate market incentives and absence of cleaner production technologies (Mbowa, 2002; Chidavaenzi, 2011; UNEP, 2004; Berkel, 1999). Moreover, most companies in Zimbabwe still lack adequate awareness and understanding of the CP concept, thereby making its implementation low if not impossible (Dandira *et al.*, 2012). In turn, most industries still rely on 'end of pipe' approaches in waste management

despite the pressing need to move from this costly methodology.

In Zimbabwe, the need for CP adoption has been increased by the stringent provisions of the Environmental Management Act (Chapter 20:27). Sino Zimbabwe Cement Company (SZCC) has not been spared from these legal requirements as high pollution levels from their operations resulted in closure of the company by the government's regulatory authority, the Environmental Management Agency in 2009. The company was implicated for causing water pollution, producing higher than normal dust emissions from its factory, discharging raw sewage and used oil directly into Kwekwe River and the surrounding environment, posing significant risk to humans, livestock, flora and fauna (Manyaza, 2009; Kusena *et al.*, 2012). The mounting environmental challenges coerced the company to implement CP in order to improve its environmental performance. The paper examined the extent to which CP improved SZCC's environmental performance.

Objectives of the Study

General Objective

- To assess the effectiveness of cleaner production options in minimizing environmental pollution from Sino Zimbabwe Cement Company (SZCC).

Specific Objectives

- To establish trends in performance of selected environmental parameters before and after implementation of cleaner production options.
- To assess the usefulness of each cleaner production option adopted.
- To establish the challenges encountered in the implementation of cleaner production options.

Methods and Materials

Study Area

Sino-Zimbabwe Cement Company (SZCC) is a cement manufacturing company. It is situated in Lalapanzi, Indiva farm about 42 kilometers to the east of Gweru City, the provincial capital of Midlands (Figure 1). The company started its operations in 2001. Other than servicing the local market, SCZZ produces approximately 900 tonnes of cement per week for export to the Democratic Republic of Congo and Zambia. The company is located at an altitude of 1280m above sea level. The soils are deep red clay and well adapted for crop production (Chigerwe, 2003). SZCC area falls under tropical savanna climate with two distinctive

seasons, cold and dry winter and hot and wet summer. The area has a mean annual rainfall of 852 mm and mean temperature of 16°C (Kusena *et al.*, 2008). The organization is located in the catchment area of Kwekwe River, a major tributary of Sebakwe River which drains into Zambezi River. SZCC is surrounded by new resettlements in which farmers grow crops and keep livestock. The resettlement area is serviced by SZCC clinic for most of its health needs. The community immensely benefited from SZCC as the company constructed a secondary school and a police base. SZCC also distribute cement in batches to the locals in order to improve sanitation through Blair toilets construction for every household.

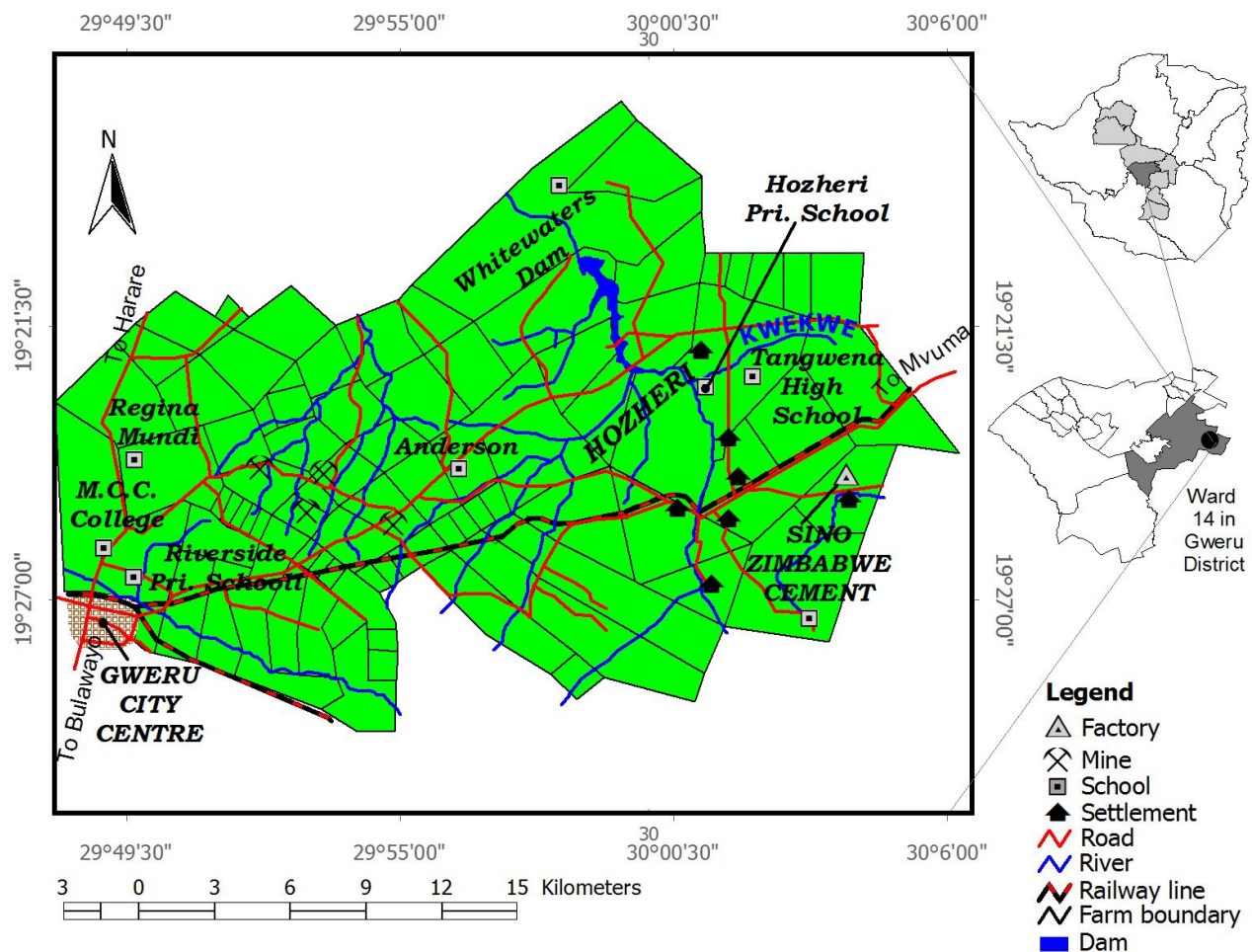


Figure 1: Location of Sino Zimbabwe Cement Company (Kusena *et al.*, 2012)

Data Collection

Both quantitative and qualitative data was collected to determine the level of CP implementation at Sino Zimbabwe Cement Company. About 72 workers were selected for questionnaires through stratified random sampling (Table 1). Workers participation was meant to gauge their knowledge on CP implementation and impacts. All household heads (17) with homesteads located within 5km radius of the company were also

targeted for questionnaires in order to gather their views on level of pollution over the years. Key informants including the organization’s Finance Manager, Production Manager, Safety, Health and Environment (SHE) Officer, Engineering Manager, Human resources Manager and the District Environmental Management Agency Officer were purposively selected for semi-structured interviews.

Table 1: Distribution of workers selected for questionnaires

Department	Number of workers	Sample size (21% of workers population)
Laboratory	24	5
Quarry	38	8
Stores	24	5
Security	20	4
Transport	10	2
Production	48	10
Warehouse	25	5
Landscaping	10	3
Marketing	6	1
Human Resource	8	2
Raw materials	30	6
Finance	23	5
Engineering	74	16
Total	340	72

The finance manager was selected because a number of CP options’ effectiveness rely more on capital injection. The production manager was targeted to reveal information on level of production before and after CP implementation. The engineering manager’s expertise was also critical in determination and implementation of CP options. Human resources manager gave information on labour turnover, appreciation of CP initiatives and provision of incentives meant to curtail human-centred shortcomings. District EMA officer provided important information on the environmental performance of the organization prior to and during the adoption of CP options. Direct observations were made on the state of the environment within and around the

organization. Lastly, document analysis based on company’s environmental records and EMA reports was done, again to ascertain environmental performance of the company since it started operations.

Data Analysis

Quantitative data from closed ended questions in questionnaires were analysed in the form of descriptive statistics whereby they were coded into percentages of respondents. Qualitative data gathered through interviews and questionnaires were organised into sub-themes for discussion under appropriate sub-headings. Quantitative data from company records on the organization’s environmental performance were analysed against environmental legal benchmarks. Some of the quantitative data

results were presented in the form of tables and graphs.

Results and Discussion

Socio-economic Status of Respondents

The findings indicated that 77.8% of the workers were males and 22.2% were females (Table 2). This was due to the fact that work in the cement industry is ordinarily laborious hence fewer women were accommodated in the production processes. A relatively few

women were therefore employed in the stores department, as secretaries and in managerial positions. About 76.4% of these workers had worked for the company for a period of at least five years, a period long enough for the workers to develop a full understanding of the processes of the company (Table 2). The findings indicated that SZCC had a stable workforce which is a prerequisite to successful implementation of innovations (Hamed, 2002).

Table 2: Socio-demographic information of respondents

Variable	Attributes	Responses	
		Frequency	Percentage
Gender	Male	56	77.8
	Female	16	22.2
Education	Primary	7	9.7
	Secondary	52	72.2
	Tertiary	13	18.1
Trained for the job	Trained	46	63.9
	Not trained	26	36.1
Period of service	≤1	3	4.2
	2-4	14	19.4
	5-7	27	37.5
	8-11	18	25
	≥12	10	13.9

The success of projects sometimes depends on the level of education and skills of the workers (Table 2). The findings revealed that all workers were literate, with only 9.7% have obtained primary education and the rest had at least a secondary education qualification. It was also indicated that 63.9% of the workers were trained and skilled for the jobs they were doing and only 36.1% were untrained. Thus SZCC had a stable and skilled workforce which made them capable to understand the magnitude of environmental problems from their organization. Besides recruiting qualified workers, SZCC conducted worker training programmes to ensure that the workers attained the prerequisite qualifications and skills.

Performance of environmental Parameters in Response to CP Options

Dust Emissions

The major sources of dust were quarrying and cement production processes. Dust emission was high prior CP adoption. This was confirmed by all key informants, 90% of workers and all surrounding households. The level of dust emission was attributed to inadequacy and ineffectiveness of existing dust reduction mechanisms. Prior to CP implementation, there were only six electronic precipitators (EP) which were inadequate to trap all the dust. The dust collectors were worn out, thus could not effectively deal with emissions problem. The plant also experienced several dust leakages along the production line due to broken pipes.

After the introduction of CP project, dust was reduced. This was attributed to increased number of electronic precipitators from 6 to 10, maintenance and introduction of more dust collectors and introduction of water spray to wash down dust from the electronic precipitators (EPs). Moreover, dust emissions from raw material storage were reduced by increased frequency of cleaning, restoring of order in stocking of material and elimination of manual off-loading. About 76% of the surrounding households indicated that dust decreased although slight deposits could be noticed on vegetation, especially grass and buildings. Most of the current dust was emanating from limestone carriers. It was observed that the carriers were not covered when moving limestone from the quarry site to the plant. Basically, reduction in dust emissions was largely attributed to good

housekeeping and to a lesser extent better processes control.

Chimneys Smoke Quality

Before CP implementation, chimney emissions were in the red band as specified in Statutory Instrument (SI) 72 of 2009, EMA (Atmospheric Pollution Control) Regulations (Chapter 20:27). This entails that the company's emissions were above 120mg/m³ and 150mg/m³ for sulphur dioxide (SO₂) and nitrogen dioxide (NO₂) respectively. Nonetheless, after CP, these parameters conformed to the blue category specifications, implying that there was 'no environmental hazard' anymore due to remediation process brought about by CP options towards emissions reduction with the exception of smoke density (Table 3). The change was largely attributed to better process control and equipment modification.

Table 3: Average air quality measurements from chimneys for period before and during CP implementation

Period	Parameters				Chimney Height
	NO ₂	SO ₂	Particulate Matter (µm)	Smoke Density (%)	
Before CP implementation	153	52	112	20	25m
During CP implementation	71	43	39	20	25m

Waste Oil Generation

Prior to CP implementation, the organization had no strategies in place to deal with oil leakages, spillages and disposal. As a result, used oil or wastewater contaminated with oil was disposed into the surrounding environment where it would eventually find its way into the terrestrial and aquatic ecosystems, especially Kwekwe river. However, the company built an oil separator tank, whereby all wastewater with oil contaminants was captured. Since oil is less dense than water, oil accumulating on-top of the water was removed using a valve on the tank side close to the top of the tank. The recovered oil was used to heat the coal mill.

Some of the recovered oil together with used oil was sold to petroleum companies for recycling. Although off-site recycling is not CP, in this case a useful by-product was recovered; hence pollution to the environment was reduced. However, oil leaks were observed from the separation tank, indicating that pollution was not wholesomely eliminated.

Moreover, routine maintenance of equipment and machinery using oil was enforced so as to minimize oil leakages, including that from trucks. Therefore, all respondents indicated that wastewater from the organization had improved in terms of colour and odour. No traces of oil were still

visible in the wastewater like in the past. The improvement was attributed to the company's significant investment in the SHE department which has been instrumental in implementation of the CP project. In brief, good housekeeping, on-site recycling and production of a useful by-product were key CP options towards reduction of waste oil.

Wastewater Generation

In the pre-CP adoption period, the volume of wastewater was high as indicated by 80% of the workers and the company records. The problem was attributed to water leakages from pumps, pipes; high volume from cooling processes and daily floor cleaning. After adoption of CP, leakages

from pipes were effectively monitored with the participation of all workers. Immediate and regular maintenance was instituted by the engineering department. The organization now recycles water from the cooling plant and cleaning.

Moreover, floor washing was reduced to twice per week. Overflows from water sprays used to suppress dust from chimneys were channeled to collection ponds and recycled. Some of the recycled water was used to clean limestone before grinding to avoid choking the shoot. On-site recycling has resulted in a decrease in both water abstracted for these activities and volume of wastewater discharged (Figure 2).

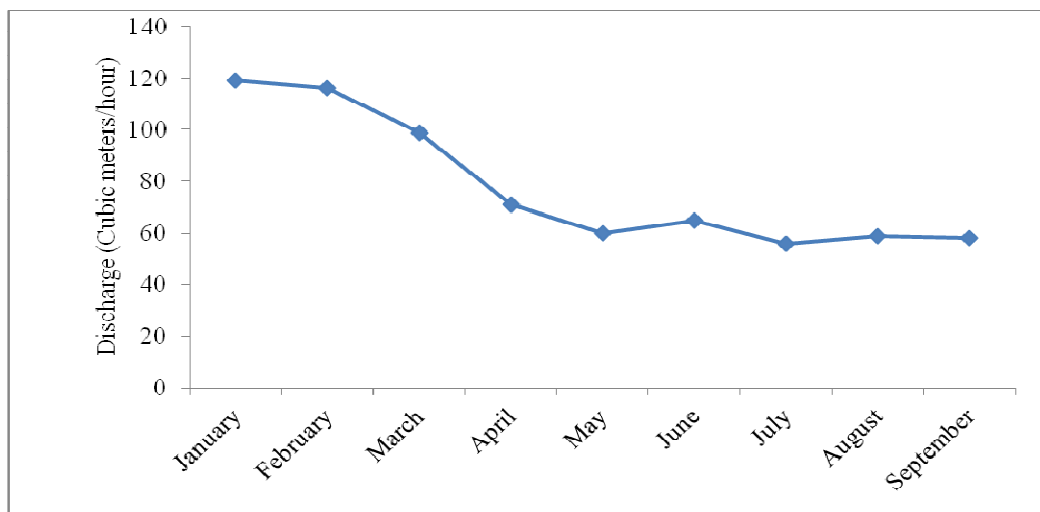


Figure 2: Average wastewater discharge between January and September 2012

Figure 2 show that effluent discharge in January 2012 was 119m³/hour. It was then reduced to as low as 60m³/hour between July and September 2012. The set target for the volume of effluent was 40m³/hour by the end of 2012. If the current trend continued to improve as in Figure 2, the target was likely to be achieved. Therefore, CP options such as good housekeeping and on-site recycling significantly reduced the volume of wastewater.

Effluent Quality

Other than volume of wastewater, the organization was also concerned with

effluent quality. EMA also monitored industrial effluent through SI 6 of 2007, Environmental Management (Effluent and Solid Waste Disposal) and SI 4 of 2011, Environmental and Natural Resources Management (Effluent and Solid Waste Management)(Amendment) Regulations (Chapter 20:27). In the period before CP implementation, overall effluent quality parameters were in the red category compared to the blue category during CP implementation (Table 4). However, it is important to note that even during CP implementation total dissolved solids (TDS)

was in the green category and conductivity was in the yellow category, meaning something was supposed to be done to improve performance in that regard.

Improvement in effluent quality was achieved through good housekeeping and adherence to operational procedures.

Table 4: Comparison of effluent quality parameters before and during CP implementation

Period	Parameters					EMA Classification
	pH	TDS	TSS	Conductivity	Chemical Oxygen Demand	
Before CP implementation	8.3	270	147	1130	178	Red
During CP implementation	7.8	564	28	1530	39.9	Blue

The water quality in Kwekwe River after receiving discharge from SZCC has improved to environmentally safe level as indicated by EMA standards. This means that aquatic life was likely to flourish in the river because of the reduction in this point source water pollution.

Steam Leakage

Prior to CP implementation, steam leakages were common due to lack of maintenance and worn out pipes. This directly increased the amount of steam consumed and raw material required for its generation like coal and water. Therefore the cost of steam production was relatively high compared to the current period whereby steam leakages were attended to regularly. All steam leakages were now reported to both the SHE and engineering departments for prompt attendance. Therefore, good housekeeping had in this case assisted the organization to deal with steam loss at low cost since monitoring was done by employees in various departments where this particular resource was required. Effective participation of workers was enhanced by SHE campaigns conducted.

Energy Consumption

Generally, energy consumption has been on a decline since 2009 when the company

increased its production when the country introduced stable multi-currency regime in order to recover from a decade of economic meltdown characterised by hyperinflation (Figure 3). What was interesting in the trends of energy use was that energy consumption was high when production was low in 2009 compared to 2012 when it was high. This was attributed to level of consciousness in the organization on the need to cut costs of production in order to increase the company’s profit margin.

The SHE department came up with daily cost-cutting measures for power consumption as from 2011. The reduction in power consumption was achieved by installing transparent sheets in some areas like mill house, bagging room and the great cooler to avoid use of lights during the day. Thus most lights were switched off during the day. During the night, lights in unoccupied offices were switched off as well. Many old pumps were replaced by new technologies which were more efficient and power saving. Many vessels and steam pipes were wrapped to reduce heat loss. Therefore, a combination of good housekeeping practices, equipment modification and technology change assisted in reduction of energy consumption.

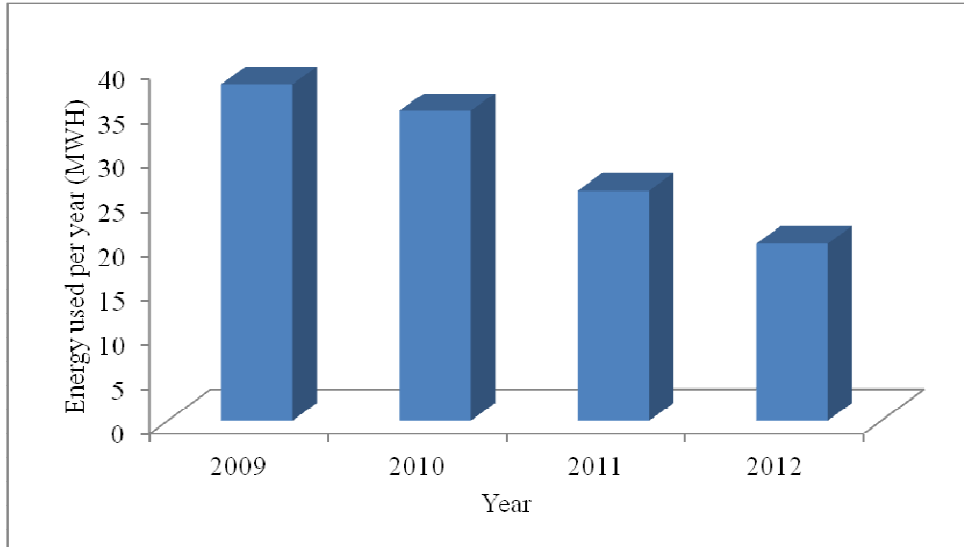


Figure 3: Energy consumption trends before and during CP implementation.
*Information for year 2012 ends in September.

Solid Waste Generation

Solid waste generated at the organization include cement, broken cement bags, plastics, falling limestone from conveyor belts, leftover food from canteen and other raw material used in cement production. About 70% of community members indicated that there was no meaningful reduction in solid waste especially broken cement bags, plastics and food (Plate 1). The aforementioned solid waste was dumped in a partially fenced open space and was periodically burned. Incineration resulted in unknown chemical

substances being emitted into the atmosphere, thereby undermining global efforts to stabilise greenhouse gases. Both livestock and people had unrestricted entry to the dumpsite. This was in contravention with the legal requirement that the company was supposed to have a lined landfill to avoid leachates. At the sametime, access by both people and livestock was supposed to be restricted as some waste could be hazardous. In brief, CP options were failing to reduce or eliminate the sources and causes of this solid waste, meaning more attention was required.



Goat feeding on waste from SZCC dumpsite

Piles of broken cement empty bags

Plate 1: Dumping site

There was also poor storage of raw materials such as gypsum, coal and limestone. These were heaped on open spaces which were not lined, a situation likely to cause underground water pollution through leachates. However, cement leakages were reduced by proper monitoring and regular maintenance of the production equipment. The introduction of CP almost eliminated disposal of expired raw materials. This was credited to the use of *'first-in-first out principle'* in which raw materials that came in first were used until they were finished before bringing in new stuff. After CP implementation, falling limestone rocks from tipping trucks began to be recovered regularly.

Moreover, blockage of shoot during limestone grinding was reduced. Limestone was now washed before grinding and the quantity of raw materials fed into the system per given time was effectively regulated. Lubricants were also introduced in order to run the grinding process efficiently, though in smaller amounts than before. Therefore, shoot operators confirmed that it was now possible to go for a week or two without the shoot being blocked. In this case waste from shoot blockage was minimized through better process control.

Clinker Falls

Conveyor belts were modified to prevent clinker falls. About 70% of the workers indicated a reduction in clinker falls since modification of the conveyor belts. However, the remaining workers indicated that the changes to the conveyor belts compromised their strength. The frequency of breakdown on modified belts was comparably higher than old ones. Sensors on the belts were now fewer and failed to effectively detect bucket overfills on time. Workers complained that the new types of belts were also difficult to work with as compared to the old type. Therefore, equipment modification could not have been

the most ideal option to deal with waste generation at this source.

Challenges Encountered in the Implementation of CP Options at SZCC

Although the organization has been reducing waste and emissions generation, pace of meeting their objectives and targets was compromised by a number of challenges. The major problem was inadequate finance as assistance from government and donor community was not forthcoming; hence the company resorted to low cost options some of which were not very effective. Mbowa (2002), UNEP (2004) and Nalukole (2000) also indicated lack of funding for CP investments as a limiting factor to success of CP projects in developing countries. At present, the company was using 6 instead of 14 limestone carriers. These were poorly serviced as there was no time for their maintenance due to pressing demand of their services. Material spillages from conveyor belt buckets were to be reduced through use of sensors to detect and prevent bucket overfilling. This was not easy to achieve, because the company did not have enough money to buy the required number of sensors to detect all overfills. Due to this challenge, spillages could not be completely avoided. Absence of competent manpower to install air bag dust collectors on chimneys was also a major challenge faced by SZCC. The company bought air bag dust collectors from China but they could not be installed due to lack of internal technical competency. The company ultimately hired technicians from China to install air bag dust collectors on the chimneys. This augments findings by Mourand (2011) that enforcement of CP options is hampered by lack of specialists.

Conclusion

Generally, the company managed to reduce both emissions and waste generation after the adoption of CP options towards the

end of 2011. The organization improved on the quality of air and effluent as they were now largely within the legal limits not detrimental to ecological integrity. Dust emissions which were one major environmental aspect from the company were significantly reduced to the delight of the local community. However, solid waste disposal and smoke density remains on the high side. The level of success depends to a larger extent on availability of finance and technical expertise.

Recommendations

- The organization must reduce generation of solid waste such as broken cement bags and plastics and oil contamination from the source.
- Limestone cleaning bay must be lined to avoid mudding of cleaned limestone before grinding as this increase water abstraction and wastage.
- The organization must thoroughly assess the feasibility of CP options to avoid adoption of options with less impact, like in the case of conveyor belts modification.
- The dumpsite must be lined to avoid leachates and protected to avoid entry of people and livestock.

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