The Impact of the Cleaner Production Technologies in the Mining Productive Chain: The Case of Padua-RJ

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Abstract

The industry of ornamental stones of Santo Antônio de Pádua, located in the northeast region of the state of Rio de Janeiro/Brazil, is currently the most important productive activity in the region. Despite this, companies make use of simple and rudimentary techniques, which causes serious environmental and competitiveness problems. In order to seek a reasonable sustainability standard for firms operating in the sector, many research, government and civil society organizations have tried to develop and diffuse technologies in order to enhance the industry’s competitiveness. However, some difficulties to diffuse technologies, especially to small companies, have arisen. The objective of this research paper is to describe and assess the use and implementation of these technologies as an important contribution for cleaner production and more sustainable approaches and attest that these technologies can represent partial solution for the practice of cleaner production systems in its broader and modern conceptualization. The research study used a qualitative approach and sought to work with multiple sources of evidence such as an extensive bibliographical review, multiple case studies with semi-structured interviews with entrepreneurs and industry professionals, in addition to technical visits to local companies. This paper considers that even with all the effort, the model used to address the lack of sustainability of the firms located in Padua was incomplete and the results were modest. The model was too focused on the technology development itself, but missing other aspects such as training of entrepreneurs and workers as well as the implementation of environmental management systems and adequate set of policies to back up these initiatives.

Keywords: cleaner production technologies, innovation, technological diffusion, mining, productive chain.

1. Introduction

The exploitation of stones in the region of Santo Antônio de Pádua, in the northeast region of the state of Rio de Janeiro in Brazil, is currently the most important economic activity in the region. This sector, according to data from DRM/RJ, comprises about 168 companies (103 quarries, 54 sawmills, 10 sand mines, 1 mineral water source). These companies are responsible for about 5 thousand direct and indirect jobs in the region, which is considered the poorest region in the state of Rio de Janeiro. According to SEBRAE, among the various specialization nuclei operating in the sector of mineral extraction that have been identified in the state, the extraction of ornamental stones in Santo Antônio de Pádua is the most relevant in terms of job generation and income in the local sphere, being very closely resembled to the definition of a Local Productive Arrangement, which is cited in the literature.
In spite of the economic strength of the sector, the mining and cutting operations, in the majority of companies (most of them micro and small sized), make use, until this day, of simple, and even rudimentary techniques, causing uncountable environmental and competitiveness problems. Aware that, even nowadays, the main problems faced by the sector have been related to the lack of a policy framework specific to the mining sector, the use of cleaner production concepts and methodologies could be a feasible alternative for the sector. However, we have been observing a concentrated effort on cleaner production technology development for the mining sector, while other aspects are still missing such as cultural and mindset change and entrepreneurs and workers training.

From 1990 to the present day, there have been many coordinated and uncoordinated interventions from the institutions of the region and the state, in an attempt to develop technologies which could be implemented in the sector. Many of these technologies may be considered successful, because they were able to solve problems faced by the sector. However, the greatest challenge of the research, government and civil society institutions is to understand that only the development of cleaner production technologies is not enough to improve the sustainability performance of the mining productive chain. It is also important to make a deliberate effort to implement cultural and entrepreneurial mindset changes to incorporate more sustainable practices into firms’ operations, which can only be achieved with education and training of entrepreneurs and workers.

Therefore, the objective this research paper, given that many specific technologies have been developed and made available for the reduction of problems in the sector, describe and assess the use and implementation of these technologies as an important contribution for cleaner production and more sustainable approaches and attest that these technologies can represent partial solution for the practice of cleaner production systems in its broader and modern conceptualization With regards to the specific objectives, this research paper intends to: describe the traditional processes of extraction and refining of ornamental stones in the region, identify the main problems in all areas of the productive chain; recognize and describe the main technological innovations and their impacts in the sector.

2. Methodology

The research study adopts a qualitative approach since it sought to obtain information and make subjective interpretations about the perspectives of individuals (entrepreneurs, policy makers and industry professionals); thereby aiming to interpret the environment of the supply chain and its problematic with regards to the difficulties of the diffusion of technologies. In order to capture the different points of view on the issue in question, the research study sought to work with multiple sources of evidence such as a comprehensive bibliographical review, semi-structured interviews with entrepreneurs and industry professionals and the participation in various technical visits. This multiplicity of sources of evidence turned out to be vital for the reliability of the results. According to Cauchick Miguel (2010), the most appropriate research methods to carry out a qualitative research are the case study and the action research. But in the case of this study, the researchers had a low degree of involvement with the individuals and organizations surveyed, thus multiple case studies (20) presented itself as the most appropriate method. The interactions took place during the technical visits, interviews, observations and document consultations. The case study is an empirical study that investigates a given phenomenon resulting from multiple sources of evidence, within a real contemporary context (Cauchick Miguel, 2010; Yin, 2001).

The research study began with the definition of a theoretical-conceptual framework by way of a broad literature review composed of articles and technical publications associated with the mining sector in the selected region. Next, a sample of 20 small businesses (from a population of 54 legal sawmills) were selected, from which data was collected (qualitative data; 20 cases) through semi-structured interviews. This approach was adopted so that researchers could gain a better understanding of the processes and problems faced by firms, the innovations and technologies developed and available to firms, and their impact on the sector.

3. The Evolution of the Cleaner Production concept and its use in the mining sector

According to the World Commission on Environment and Development (1987), sustainable development is the “… exploitation of resources, the direction of investments, the orientation of
technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations. (It is) meeting the needs of the present without compromising the ability of future generations to meet their own needs”, several institutions from multiple streams have been trying to achieve social changes through the involvement of all sectors of society in a spirit of shared responsibility, including public administration, public and private enterprise, and the general public (as both individual citizens and consumers). These conclusions and initiatives continue to gain momentum in the last few decades through events such as the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 and the Rio +20 in 2012. The key conclusion is that economic development cannot be disconnected from environmental considerations. The first initiatives back in the 80’s were more focused on pollution control and the introduction of environmental technologies was focused on the prevention of pollutants coming into the air, soil or water, but not on the prevention of the ‘production’ of the pollutants themselves. The scope of these initiatives has evolved in the last few decades and the literature highlights three major shifts in the development of environmental technologies (Dieleman and Baas, 1991 apud Bass, 1995):

1. From pollution control and waste handling technology after pollutant generation, to proactive, process-integrated technology that prevents the generation of pollutants at source.
2. From a sole emphasis upon technological measures to a broader perspective which also encompasses non-technical measures.
3. From consideration of only the environmental aspects of the manufacturing process, to consideration of the environmental aspects of the entire life cycle of products, including product design, sustainable resource management, consumption and post-consumer management of the used products.

A of the most modern perspective conceives a clean environment as a resource, which can be renewable or non-renewable. In this way, the renewal of an ecosystem may be more difficult (or impossible) than recovery of a polluted river. With respect to this the World Commission on Environment and Development (WCED, 1987) stressed, on an abstract level, the urgency of meeting the needs of present and future generations in an environmentally sound way. Industrial operationalization of Sustainable Development is being developed via cleaner technologies and products. By sharing responsibilities for the environment at all organizational levels within companies, by substituting toxic compounds and applying renewable energy and environmentally sound technologies, new environmental management instruments are developed. 'Cleaner Production' concepts cover this internalization of environmental effects in new management approaches. (Baas, 1995)

The origin and subsequent introduction of Cleaner Production into the environmental management literature occurred as a result of the work of a band of international agencies in 1989 – namely, the United Nations Environmental Program (UNEP), and United Nations Industrial and Development Organization (UNIDO). However, in most cases, UNEP is credited with having first used the concept, initially defining it as a “preventive strategy which promotes waste before it is systematically created, to systematically reduce pollution, and improve the efficiencies of resource use” (UNEP, 2001, p. 3 apud Hilson, 2003).

Baas (1995) defined Cleaner Production as the conceptual and procedural approach to production that demands that all phases of the life-cycle of a product or of a process should be addressed with the objective of prevention or the minimization of short and long-term risks to humans and the environment. The literature is replete with scholarly interpretations and assessments of Cleaner Production. However, despite the multiplicity of interpretations, the concepts of Cleaner Production have evolved substantially. In 1992, the UNEP IE/PAC Newsletter of Cleaner Production contained four additional statements designed to answer the question 'What is Cleaner Production?': (Baas, 1995)

(a) Cleaner Production means the continuous application of an integrated, preventive environmental strategy to both processes and products to reduce risks to humans and the environment;
(b) Cleaner Production techniques include conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emissions and wastes;
A Cleaner Production strategy for products focuses on reducing environmental impacts throughout the entire life cycle of the product - from raw material extraction to the product's ultimate disposal; Cleaner Production is achieved by applying expertise, improving technology and changing attitudes.

Upon analysis, it is clear that these statements represent different dimensions of the preventive approaches of Cleaner Production. During this evolution process, the behavior of the organizations has been changing as well. The attitudes of company leaders towards the environment may be characterized by four different levels: (Baas, 1995)

1. Compliance with present regulations;
2. Receptive anticipation of increasingly stringent regulations;
3. Constructive development of new concepts;
4. Internalization of environmental stewardship thinking and action.

The first two levels can be found among industrial policies and practices. While most company leaders are acting at level 1 or partly at level 1 and partly at level 2, a few companies are evolving and implementing policies and procedures towards level 3. Level 4 is still exceptional; examples of this level are companies with an ecophilosophy. These levels are usually the phases through which a single company develops its environmental policy, as shown in Table 1 with the trend in new response patterns (Winsemius, 1994 apud Baas, 1995).

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<th>Response pattern</th>
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Table 1: New business approaches toward environmental issues

Source: Baas (1995)

According to Baas (1995), the most interesting level, and in relation to Cleaner Production the most important, is the 'internalization of environmental stewardship thinking and action', the appropriate vision to integrate the needs within the society with ecologically sound activities. In companies that develop and implement the more proactive approaches of Cleaner Production, a continuous improvement chain is developed which encourages innovations, improves productivity, improves product and service quality, achieves service excellence, increases readiness and survivability, decreases costs and improves the corporate image. However, despite this evidence, even nowadays, in many companies, especially in the mining sector, reactive practices are still dominant, while the new Cleaner Production awareness, which demands new practices and a new paradigm, has not been accepted by them or by most governmental officials.

Despite Ashford’s (1994, p. 4 apud Hilson, 2003) claim that Cleaner Production "can be applied to the processes used in any industry" and the fact that successful examples of cleaner production and sustainability initiatives in Brazil are not rare (Matos and Silvestre, 2012; Silvestre and Dalcol, 2009), the nature of the mining sector’s operations, combined with the inability of its sites to avoid environmental impacts, renders many existing interpretations (of Cleaner Production) highly unsuitable. Another problem is the fact that several interpretations of Cleaner Production appear almost entirely prescriptive for manufacturing and service sector firms. Although there is clearly a need to redefine the concept specifically for mining, few have attempted to bridge this gap in the literature. In addition, Cleaner Production has generally been interpreted in the mining context in an excessively cavalier manner. Most of the assessments made to date have emphasized effect, rather than definition. In the majority of cases, these, and related efforts, merely provide a brief overview of existing definitions of Cleaner Production and describe recent advances in the industry's environmental technology, in turn, leaving the reader to draw a link between the two areas. Few have attempted to describe explicitly how mines can achieve Cleaner Production, as well as how the concept can be both effectively incorporated into national mining polices and embraced at the institutional level. (Hilson, 2003)
According to Hilson (2003), in the mining context, Cleaner Production is increasingly being associated with environmental improvements resulting mainly from technological diffusion and modification; this is evidenced in both the agendas of international Cleaner Production conferences, and industry analysis undertaken by influential institutional bodies. The tendency to view technological change as the sole catalyst for achieving Cleaner Production in the mining industry has, in turn, resulted in its progressive disassociation with the non-technical changes—namely, training, education, and makeshift alterations in managerial practices—capable of facilitating equivalent degrees of environmental improvements.

Hilson and Nayee (2002, p. 22 *apud* Hilson, 2003) argued that Cleaner Production in the mining industry is “a superior level of environmental performance, which can only be achieved through improved strategy and housekeeping, sound process control, optimized plant layout, and the implementation of efficient management techniques”. The authors further indicated that attaining Cleaner Production at mines requires adopting a “lateral thinking approach”, and “implementing processes and products that are designed from their inception to minimize risks to the environment and human health”.

Hilson (2003) argues that if the mining industry is to achieve the targets set out in the UNEP’s general definition (of Cleaner Production)—arguably the most credible interpretation in existence—improved managerial techniques and training programs must accompany the implementation of state-of-the-art environmental equipment at sites. More specifically, technology alone is incapable of “(promoting) waste before it is systematically created ... systematically (reducing) pollution, and (improving) the efficiencies of resource use” (UNEP, 2001, p. 3 *apud* Hilson, 2003) in the mining industry. Hilson (2003) therefore postulated in his paper that, because of the wide range of changes required when applied to mining, Cleaner Production should be viewed as an overarching environmental strategy emphasizing improvements to mining operations and processes, and the adoption of highly effective environmental management strategies. To achieve Cleaner Production, mine management must continuously assess the suitability of input materials, the designs of operations, energy and material inputs, and waste disposal techniques. For the author, Cleaner Production extends beyond the technological and design-related characteristics of the industry, focusing equally upon key managerial and policy-making aspects such as the implementation of management systems, environmental tools and processes; makeshift changes in attitudes; and the application of “know-how” to managerial techniques and housekeeping practices.

The challenge of this paper is to highlight and understand that only the development of cleaner production technologies is not enough to improve the sustainability performance of the mining productive chain. It is also important to make a deliberate effort to implement cultural and entrepreneurial mindset changes to incorporate more sustainable practices into firms’ operations, which can only be achieved with education and training of entrepreneurs and workers. In the following sections we introduce the main processes of mining productive chain of Santo Antônio de Pádua – RJ, and the dynamics associated with it as well as the cleaner production technologies and their impacts on the sector. Next, we develop the analyses, which make evident that even with all institutional and organizational efforts, firms and the productive chain did not evolve as expected in terms of sustainability performance due to the use of an incomplete approach to cleaner production.

4. The Mining Productive Chain in Pádua and its Environmental Impacts

4.1 The traditional processes of extraction and refining

The traditional processes of extracting and refining rocks for the production of ornamental stones in the municipality of Santo Antônio de Pádua, that remain in all companies of the region, even those that have acquired new equipment and have implemented innovations, is still little mechanized and mostly handmade. The first activity of the process is the extraction of blocks of rock from the field. The basic extraction technology employed by the majority of companies consists of the detonation of the bedrock, which is very often done rudimentarily (by trial and error), which reduces the economical value of the blocks, because they may present cracks and not uniform edges, and causes severe environmental damages. In a second phase of the extraction, a worker, with the aid of a sledgehammer and chisel, removes small blocks of 50cm x 50cm x 40cm size from the bigger blocks. After the extraction of these small blocks, they are manually sliced into plates by a worker, with the aid
of a sledgehammer and a chisel. The stone plates are then transported by truck to the refining companies where they are cut with small saw machines, equipped with a diamond disk, into the fine dimensions of an ornamental stone. Finally, these little plates are once again sliced manually. This procedure produces the end product – the plates of ornamental stone. After the refining, the products generally a commercialized by companies in the region are: Plate, 47 x 47 x 4 cm; Block, 23 x 11.5 x 4 cm; and Brick, 23 x 11.5 x 1.5 cm, or 11.5 x 11.5 x 1.5 cm. (see Fig. 1)

The Severe Environmental Problems Caused by the Traditional Processes

As previously mentioned, due to the lack of technology in the processes described above, the loss of raw material is very high throughout the supply chain. During the extraction the loss might be of about 30%. Besides the economic losses, the loss at this point of the process causes irreversible and severe environmental impact. Once the rocks have been extracted, the extraction area becomes useless, with no alternative use, since the stones are spread on the entire area. During the refining, the problem is even bigger. The loss of raw material may reach 50%. The result of this problem is mountains of debris irregularly disposed in abandoned lands beside the roads of the region. Also during the refining, besides the loss of raw material, there is the release of dust from the stones from the saw machine. This dust, with a very fine granulometry, is inappropriately disposed together with the water used in the process, as mud.

According to Ribeiro et al. (2005), this mud is mostly constituted of water, grit, lime and smashed rock (aluminosilicates, feldspar and quartz), which after the process are disposed in the environment. After the evaporation of the water, the resulting dust spreads, contaminating the air and the water resources. In some cases, the resulting mud is directly channeled to rivers and lakes, causing a serious environmental problem. These serious and recurring environmental problems have caught the authorities’ attention since the 1990s. The authorities, through environmental laws, started to fine and close the sawmills and quarries which disposed their rejects inappropriately in the environment.

4.2. The Technological Innovations in the Sector and Their Benefits for the Productive Activities and the Environment

The process of meeting and supporting the manufacturer of ornamental Stones in the region of Santo Antônio de Pádua began in the late 80’s, by DRM-RJ (Departamento de Recursos Mineiros do Rio de Janeiro). At that time, the non-articulate action of institutions and local government did not help to minimize the problems in the sector, mainly due to the great expansion in the quantity of production areas and the addition of young miners to the business; all similar to the mining phenomenon. Thus, the implementation of technological innovations was scarce till the mid 90’s.

Back in that time, the Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (SEBRAE–RJ) and the Associação de Empresas de Pedras Decorativas (AEPD) were able to sign a contract with the Centro de Tecnologia Mineral (CETEM) in order to try to solve the problems that companies in the region were facing (Almeida et al., 2001). From the problems diagnosed, the CETEM developed works for the improvement of the production of the quarries, especially the aspects related to the extraction of rocks, the safety of workers and the treatment of effluents. These actions, though considered of low impact by some entrepreneurs of the sector, were continued in the project Rede de Tecnologia Mineral – RETECMIN. The RETECMIN was a technology cooperative network for the support of the Productive Sector of ornamental Stones in the state of Rio de Janeiro. This network included: DRM (Departamento de Recursos Minerais), INT (Instituto Nacional de Tecnologia), UENF (Universidade Estadual do Norte Fluminense), UFRJ (Universidade Federal do Rio de Janeiro), CETEM (Centro de Tecnologia Mineral) and FIRJAN (Federação das Indústrias do Estado do Rio de Janeiro). Despite the broad articulation, the RETECMIN was largely criticized by some entrepreneurs for not providing quick and practical results.

Another institution which intervened in the sector in the late 1990’s, not involved with RETECMIN, but with other agencies like SEBRAE, FINEP and FAPERJ, was the ETFC – Escola Técnica Federal de Campos, currently known as IFF – Instituto Federal Fluminense. Therefore, after the effort to identify the main problems of the sector, several applicable researches have been developed by institutions of the region aiming to find viable alternatives for the use of residues of the extraction and refining processes of the ornamental stones and for the improvement in the competitiveness of the companies. The
technological innovations made available through those researches and to be used in the supply chain of ornamental stones in Santo Antônio de Pâdua can be organized according to Fig. 1. The key cleaner production technologies are described further below.

**Fig. 1:** Available Technologies for the supply chain of Ornamental Stones in Santo Antônio de Pâdua.

Segregation of fine solids (Effluent Treatment Units) and their use in mortar for Construction (Mortar Factory): One of the first and most important projects, within the associations of RETEMIN, was the “Segregation of fine solids and their use in mortar for construction”, a technology developed by CETEM which proposes the use of fine grained gneiss in the production of mortar. In the first phase of the project, CETEM elaborated a system for the treatment of liquid rejects in order to avoid the disposal of such rejects into the rivers of the region of Santo Antônio de Pâdua. The cutting equipment of the companies were, and still are, obsolete since they do not take into consideration the capture and reutilization of water and the fine rejects of the slicing process of stones. These became one of the main legal/environmental problems, due to the intervention of the Public Ministry. At this phase, according to Peiter (2000), RETECMIN was very successful for establishing a simple and low cost process for the collection, cleaning and recycling of water originating from the sawmills – the effluent treatment units, also known as settling ponds.

In the second phase of the project, the researchers searched for alternative uses for the fine solid rejects resulting from the first phase of the project. The results demonstrated that the fine grained gneiss could be used as an alternative to lime in mortar production, a solution achieved by CETEM along with UENF. The study demonstrated the investment’s feasibility and caught the attention of the local community and Public Ministry, for the promise of lowering the level of pollution of the Pomba River, which is usually harmed by the disposal of residues (PEITER, 2000). Thus, after the demonstration of the project feasibility and with the support of INVESTRIO, the institutions were able to convince a private group located in the region, Mil Group, to invest in the construction of a mortar factory, ARGAMIL, which is still operating by collecting fine residues of several sawmills.

The Gantry Crane, the Hydraulic Gripper and the Bridge Saw: Another important public intervention in the sector, also outside the sphere of articulation of RETECMIN, happened in the late 1990’s, when the so called ETFC – EscolaTécnica Federal de Campos, nowadays known as IFF – Instituto Federal Fluminense, supported by SEBRAE and FINEP, developed, for a consortium of entrepreneurs, a group of equipment which allowed a new layout and a new physical arrangement for the unloading of the blocks removed from the field and taken for refining in the sawmills. The first equipment was the Gantry Crane, used to unload blocks from the truck and move them transversally, longitudinally and vertically. In order to develop a gantry crane able to comply with the technical demands of unloading and cutting blocks of ornamental stones, a technological innovation was required – the “Hydraulic
Gripper”, a mechanism able to unload large blocks of ornamental stone (SILVA NETO, 1990). Yet, in the sawmill, another innovation adopted by the consortium of companies, was the importation of a circular saw of high precision, also known as bridge saw, which is able to cut large blocks of stone. (Silva Neto, 1990). After the implementation of such equipment, the whole extraction and refining processes was revolutionized, because the unloading of blocks from the trucks and their placement upon the bridge saw, by means of the hydraulic gripper, allowed the companies some other benefits.

Gravel Plant which uses crushed rejects from the quarries and sawmills: The rejects of quarries and sawmills, as mentioned before, are inappropriately disposed along roads or in abandoned lands, causing a significant environmental impact. A technically viable alternative for the use of such rejects consists in crushing such material so as to produce aggregates for construction: gravel stone, sand and dust. In 2010, supported by the Serviço Nacional de Aprendizagem Industrial (SENAI) and funds from FAPERJ, a Gravel Plant was installed close to the Raio do Sol Sawmill, in Pádua. After crushing the rejects, three materials are produced: Gravel 2, which is mainly used in asphalt cement, Gravel 1, which can be used in cement, asphalt and precast, and stone dust, usually used in the production of mortar and precast. The results of analyses suggest that the material is suitable for construction, even though it is limited to small and medium sized constructions.

The mobile crusher machine: Another initiative of IFF, which took place in 2010, was the development of the mobile crusher machine with funds of FAPERJ, through the Technological Innovation Announcement 2010. According to Silva Neto (2012), the project aimed to design, develop and build a mobile crusher machine to process residues originating from both the extraction and refining processes, complying with the technical characteristics of the rocks of the region, with the objective of producing material suitable for paving country roads of the region. This processing of residues, which changes them into sub products for paving, reduces environmental impacts originating from residues disposed at different locations of the region and also increments the availability of raw material for paving the country roads. The greatest advantage of the mobile crusher machine in face of the Gravel Plant is that the equipment can be transported to the places where the residues are deposited so as to crush them at the same location, and placing them close to where they will be used, thus decreasing the costs of transportation.

The slab opener: This ongoing project, is another initiative of IFF and is also supported by FAPERJ, which aims to project, develop and build a “Hydraulic Machine able to slice Ornamental Stone” with the objective of increasing the productivity, reducing waste and improving the quality of end products of the ornamental stone industry. The results expected from this equipment, which is still being developed, are: an increase in productivity of plates, once this process will be performed by a modern and precise equipment; reduction of waste, once most of the handmade cuts will be avoided, causing a reduction in the amount of rejects; and consequently, the reduction in the environmental pollution (Silva Neto, 2011). This equipment is considered by the entrepreneurs as the most important innovation for the sector, because currently the main problem faced by the companies is the lack of specialized workforce able to open blocks into slices.

4.3. Innovation and Technological Diffusion – Challenges for the Padua Mining Productive Chain

The Technological Innovation increasingly assumes the role of the key-resource in the organizations and a source of a competitive advantage. Mueser (1985) defines technological innovation as "a new idea, a discontinuous technical event, which after a certain period of time, is developed until the time comes in which it becomes handy, and is then used successfully." On the other hand, Rothwell and Gardiner (1985) point out that innovation does not necessarily mean the commercialization of only major technological advances, but also includes the use of small-scale changes in technological knowledge. Utterback (1983) suggests that technological innovation is understood as a process that involves the creation, development, use and dissemination of a new product or idea, or the introduction and diffusion of new products and processes which have improved in the economy. Nevertheless, a Technological Diffusion can be conceptualized as the process by which an innovation is communicated over time, through certain channels, among members of a social system (Rogers and Schoemaker, 1971). However, Tigre (2006) states that “the processes of innovation and diffusion cannot be completely separated, because in many cases diffusion contributes to the process of innovation”.

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Based on the technical visits and the interviews with entrepreneurs of the sector and with professionals of the supporting institutions, it became evident that despite all of the efforts of the institutions to raise funds and to develop technologies to minimize the problems of the sector, these are not widely widespread. Factor such the lack of qualified workforce, lack of market information and the resistance to changes in the company, were the main obstacles to the technological diffusion in the sector (Silvestre and Silva Neto, 2012). In some cases, the economic factor, 'too expensive', was a barrier to diffusion. These factors are defined by OECD (2005) and by Murillo-Luna et al. (2001) as barriers to adoption of proactive environmental strategies. However, obstacles such as lack of appropriate funding, hard to control expenditures on innovations, insufficient innovation potential, or even a lack of technological opportunity were not observed during the interviews and technical visits. These results indicate that there is broad availability of public resources for technological innovation, as well as the capacity and initiative on the part of research institutions to develop technologies for companies.

Therefore, the survey results point to the need for interventions to be made in the companies, in view of the fact that the company factors were the main obstacles to the diffusion of technology. In particular, one can highlight the need to increase the level of education and qualification of entrepreneurs and workforce in the sector, as well as to provide specific training with regards to technological innovation. The analyses indicate that these technologies have mainly assisted the large and well organized companies, but their diffusion to micro and small companies is ineffective for many reasons, such as: resistance to make changes in the company and the entrepreneurs lack of access to the research institutions. Furthermore, the articulations try to solve specific problems in the supply chain, without using an integrated approach of the activities carried out in the supply chain. Thus, it is possible to identify the lack of a sector based policy regarding the transference of technology to all companies of the sector, in all areas of the supply chain. This paper argues that development and availability of cleaner production technologies is not enough to improve the sustainability performance of the mining productive chain. It is also important to make a deliberate effort to implement cultural and entrepreneurial mindset changes to incorporate sustainable practices into firms’ operations, which can only be achieved with education and training as well as a set of policies to back up the initiative.

5. Cleaner Production in the mining industry

According to Hilson (2003), mining Cleaner Production practices can effectively be divided into three separate categories. The first group, “managerial changes”, refers to environmental management-related initiatives that improve the overall efficiency of operations, and which require the participation of staff. Each must be redesigned differently to conventional models, simply because mining consists of four stages (exploration, approval, operational and closure). This, in turn, necessitates the development of a more procedurally complex and comprehensive environmental management strategy. One important “managerial change” – and inevitably, a tool for achieving Cleaner Production – is the implementation of an environmental management system (EMS), which is the component of the overall management system that includes organizational procedures, environmental responsibilities, and processes (Begley, 1996 apudHilson, 2003). Furthermore, regarding “managerial changes” we should also add education and training for employees and managers and organizational commitment to provide direction to employees operating on all levels.

The second group of elements, “policy changes”, emphasizes the environmental decision-making aspect of operations. Principal examples include corporate environmental policies, voluntary impact assessments, environmental audits, and reviews. (Hilson, 2003) Specifically, these initiatives seek to identify appropriate technological measures for implementation, as well as areas in need of further improvement. For example, many mining companies have elected to draft environmental policies, which help to provide a much-needed course of direction for activities, covering the areas of operation, environmental assessment, documentation, regulatory compliance, and “ethical” responsibility.

The third, and final, group of elements, “physical changes”, include technological modifications, implementation of state-of-the-art equipment, and process-related initiatives. However, the implementation of these and related “Cleaner Production technology types” is a means of achieving pollution prevention, and there are obvious differences between the concepts of pollution prevention and cleaner production, particularly in terms of scope. (Hilson, 2003)
Based on the discussion above regarding the mining productive chain in Padua, we observed that the efforts made by the institutions targeted basically “physical changes” (Hilson, 2003), with the focus on the development of cleaner production technologies. However, significant difficulties were encountered to diffuse these technologies. This fact was observed while no initiative regarding “managerial changes” or “policy changes” was identified during the field studies. We argue that the lack of knowledge of firms and institutions about the cleaner production concepts and methodologies hindered the synergies and the positive effects these technologies could have in the mining productive chain.

5. Conclusion

The concept and methodologies of Cleaner Production have evolved significantly in the last few decades, yet their application in the mining context still remain under the radar for firms and institutions in developing countries. It is not rare institutions, firms and government undertaking an articulated effort with the focus almost entirely on the technological aspects. In Padua, the same thing happened: localized efforts to solve punctual problems in the productive chain, yet no initiative regarding “managerial changes” or “policy changes” were identified. This was in part the result of the lack of knowledge from the actors involved about concepts and methodologies associated with Cleaner Production. We argue that the development of cleaner production technologies is important, but the missing aspects of the approach adopted brought significant drawbacks for the whole initiative. We suggest that a workshop with all actors involved could be a milestone to change the course of the mining productive chain in Padua toward cleaner production and sustainable practices.

References

Silva Neto, R., 1990. Projeto de uma Ponte Rolante para descarga e corte de Pedras Decorativas. Relatório Técnico para SEBRAE.


