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Environmental technologies used for the mitigation of industrial environmental impacts

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ABSTRACT

With the growth of the world population, constant technological evolution and consequent change in the habits of our society, human activity is gradually increasing its capacity of alteration to the environment. Small acts of environmental preservation result in great feats for the ecosystem, for humanity and are preludes for the continuity of life. This study discusses the dispersion of pollutants caused by industries, the importance of the remediation technologies used, which can prevent and / or mitigate the impacts that are caused to the environment. This study is a comparison between end-of-pipe technologies and cleaner production, which are the most used by industries. It was based on the environmental impacts caused by the industries and on the most used remediation technologies as mechanisms to reduce or prevent these impacts.

Keywords: Remediation technologies; Environmental impacts; Pipe end technology; Cleaner production

1 INTRODUCTION

The introduction of global industrialization shows the prevailing role in the technological development of radical changes in human societies. Subsequent economic and technological development, based on intensive use of raw energy and energy, increased the capacity to use natural resources.

In addition to the intense use of natural resources, the waste from the production processes in the environment resulted in the accumulation of pollutants above their absorption capacity, generating pollution. Moving from a local perspective, degradation of soils, water bodies and air quality to a global regional dimension. These negative effects on the environment are the result of past decisions and actions, suggesting a temporal interdependence, that reveal a process of continuous changes and evidences uncertainties regarding the knowledge of the environmental impacts resulting from economic growth.

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Even a technology, using intensively natural resources or even recruting the tailings of productive functions to the environment, not causing environmental impact. This increase is continuous to generation tending to wanting the main quantity of natural resources, thus being dumping more waste in the environment. This increase is associated with the growth of the capitalist population, the Industrial Revolution.

The growth of capitalist production depends on new markets and therefore on the creation of new needs for consumers. Thus, the needs of the population increase along with the scale of industrial production, the demand for natural resources and the rejects of productive processes. Even though industrial technological development is the focus of this article, making comparisons between them, to what better shape and situation do they fit in the industries. Of course, it is the approach of the environmental issue from the point of view of industry that does not exhaust the discussion about sustainability, since the behavior of consumers and other economic sectors are decisive.

With specific objectives of this study, we sought:

- Analyze the current panorama of environmental technologies;
- Analyze the phases that make up the environmental impact generated by the industries;
- Possible solutions that help mitigate these impacts;
- Technologies that increase the useful life of the products, with the aim of reducing the consumption of raw materials, reducing the volume of waste;
- Compare the following technologies: Cleaner Technology and end-of-pipe technology

1.1 Industry and Environment

The nature of environmental problems is partly attributed to the complexity of the industrial processes used by man, using the various technological resources. Pollution of consumer goods has grown in large proportions and, with it, consumption of natural resources. Environmental complexity is caused by the fact that the extraction and use of these resources compromise the existence of creatures living in interactive systems (ecosystems). In addition, the generation of waste by industrial processes also affects the survival of organisms in ecosystems, changing the food chain in an often-unpredictable way.

From the Industrial Revolution, the acceleration in the increase of the human activities cooperated so that great amounts of resources and energy obtained increase in the consumption in a short time. Large-scale production and mass consumption have significantly influenced the planet's environment, generating a scarcity of nonrenewable resources and causing environmental problems that have culminated in air, water and soil pollution (NOWOSIELSKI & BABILAS, *et al*., 2007).

With all these causes of damage to the environment, environmental problems began to be debated by non-governmental organizations (NGOs) and academic circles from the 1970s onwards. This historical evolution led to the development of norms in the environmental field. In this way, managers began to worry about the management and implementation of an environmental management system as a strategy, with the purpose of obtaining competitive advantages and reducing the environmental damages generated by the industries (TINOCO & KRAEMER, 2008).

The concern of industries with the environment includes the need for ecological, safety, consumer protection and advocacy practices and strategies, and product quality. In recent years, organizations have been pressured to seek to apply values in their administrative, commercial and operational activities (DONAIRE, 1999).

The great growth of industrialization, coupled with the acceleration of population growth, urbanization, agricultural modernization, production, and consumerism of the population, tend to be an aspect of the historical evolution of human societies that develop economically, which result in the degradation an environmental unprecedent (ENGEP 2002).

It can’t be denied that industrialization was of major importance in the lives of human beings, but the responsibility was disastrous, which brought risks to those who benefited from it. The negative consequences not only result in technology and science itself, but also in the lack of more organized culture and equality in respect to all living beings (PIRES, 2011).

Industrial civilization has accentuated the dialectic between "human needs" and "impact on nature". The great exploitation of these natural resources to the growing human needs are met, the exacerbated increase of the population, the exploration and use of new sources of energy, the evolution of technologies with impact on the environment, the increase of the difficulty of the social systems by the apparition of social classes and the absence of alternative ways of life due to the cultural population, all lead to a growing question about the interaction between the environment and human society, causing divisions and discrimination. The ecological crisis does not consist merely in the appearance of environmental problems, but in the primordiality of new ways of seeing the world, and especially nature (JUNGES, 2004).

Reducing pollution through conscious consumption of raw materials, energy and water, is a definitive environmental and economic alternative. Minimizing waste results in greater efficiency in the industrial process and lower investments to elucidate environmental problems.

As competitive actions in this environment, which often consists of opportunities and also threats to any kind of change, industries insert environmental strategies to reduce costs and risks, increase incomes and untouchable assets to address the needs of stakeholders. Such strategies generate a new type of competitive income, which are called Eco-advantages or "ecostrategies" that allow industries to reach the levels of excellent performance, profitability and growth, bringing together issues such as quality of life at work, environment environment and safety as part of a responsible posture (BARBIERI, 2006).

The industrial area is the one that causes the most damage to the environment, either by its productive developments or the manufacture of products that pollute, and that has the problems of final disposal after its use. While on the one hand the technologies followed lead to environmental devastation, for another hand they enabled greater action in the use of natural resources and a substitution of inputs in the productive process. A striking example concerns is that it has a power to extract petroleum by-products and its partial influence on energy sources after the first oil shock in the 1973. However, technological development towards a less environmentally destructive energy pattern is seen as a partial of the problem (MOTTA, 1995b)

In the face of human interference with the environment, the following question arises: "How to assess the environmental impacts of human activities?" After all, we know the complexity of ecosystems, the interference of one another and the spread of environmental impacts along ecosystems.

What causes waste generation is:

- Raw material not used;
- Impurities in the raw material;
- Auxiliary materials used;
- Maintenance waste;
- Starting or stopping materials;
- Handling materials;
- Stocking;
- Sampling materials;
- Analysis materials;
- Losses due to evaporation;
- Transport;
- Leakage materials;
- Packaging of inputs;

The environmental impacts caused by the extraction and production of raw materials are also studied. The possibilities for reducing the environmental impacts caused by the generation of the product must also be evaluated. Through the techniques of "Life Cycle Analysis" (LCA), one can analyze a product, service, process or technology (HELSINK, 1996).

1.1.1 Life Cycle Analysis

The principles surrounding the LCA technique were developed in the United States in the late 1960s, where It was used to assess the environmental impacts of products. The focus of the studies was mainly on energy consumption, due to the first oil crisis. Little was know about the environmental aspect of various processes, so a quantitative analysis of the environmental impacts of the product life cycle was practically impossible.

In the early 1980s, European public opinion was beginning to warn of the increasing use of resources for the production of packaging. Several European countries have conducted studies to assess the environmental burden and potential impacts from beverage packaging. These studies have helped to consolidate the principles surrounding LCA and led to the cycle of various materials used in packaging.

The LCA is also known as the cradle to grave, where the cradle indicates the source of the primary inputs through the extraction of natural resources, and the grave refers to the final destination of the waste that will not be reused or recycled. This type of cycle is not confused with the market cycle, in which a certain product, like a living being, follows a cycle from its introduction in the market (birth) until its withdrawal from the market (death), passing through growth of demand, maturity and decline (BARBIERE, 2007).

Only recently has ACV been drawn to its acceptance and use. In order to facilitate the use and application of the standards, some softwares have been developed that carry out an environmental assessment based on the selection of environmental impact categories at the local, regional and global levels.

1.2 Development of Environmental Concerns

This period was characterized by total inertia to the damages resulting from the disposal of waste in the environment. Raw materials and energy were extracted from nature, which were transformed into products, and the leftovers that were generated by the process were released into the environment. From the moment the environment pointed to signs that it was not capable of capturing the amount of pollutants dumped, industries were forced to abide by measures that would reduce impacts by force of law or regulatory mechanisms, thus including the impact environment in the aspect of operation and production costs. In response, some potentially polluting companies have begun to apply palliative methods, such as the dilution of waste in a way that masks the environmental impacts of their activities (SANTOS, 2005).

As a consequence of cumulative procedures of several decades, today there is a condition of saturation of the environment, saturation is due to the proportion that industrialization has taken and the migration of the population to the great centers.

Variations in the atmosphere and biosphere are the consequences of this cumulative process and the global proportion of industrialization and the slow progress of effective models of environmental management. As predispositions that reflect in measures of environmental leadership, one can face as condemnation the successful treatments of environmental management (ROCHA, 2010).

In the current context, the interest in Brazilian and global companies has been focused on investments in sustainable practices with adequate environmental management. However, this analysis is based on four years of results obtained through research, which investigated environmental practices in large Brazilian companies. However, in the period from 2007 to 2010, there was stability in the data presented, which indicated that the signs of advancement and the policies that were established by the companies could be considered solid.

In this sense, these actions help companies to organize themselves to control their processes with regard to the environment. In this way, continuous improvements can be proposed that help in the pursuit of sustainable development.

In opposition to this "technological optimism" are the conservationists, who have put the question of sustainability in the research of different areas of knowledge in the 1960s, such as Herman Dal, Kenneth Boulding and John Krutilla. They believed that natural resources can't be perfectly substitutable because they have particular characteristics. Therefore, it would be practically impossible for humans to reproduce these resources in a synthetic way. When consumed, these resources do not return to what they were characterized by irreversibility: consumption today makes the consumption of future generations unfeasible (SCHMALENSEE, 1990).

After three decades of debate on the environmental limits of economic growth, it was realized that growth was not reached, but rather the technological standard adopted by industrialized countries. In other words, economic growth based on an intensive technological standard in the use of raw materials and energy, mainly from hydrocarbons - great demands on natural resources - can be found within the limits of environmental resources (LUSTOSA, 1999).

1.2.1 Pollution control

The most incipient stage of environmental management corresponds to pollution control practices. In this first moment, there is no genuine concern with nature, but rather the need to respond to social demands and obligations imposed by law. Rather than presenting an articulated set of measures, one only seeks to perform isolated actions, reducing the discharge of pollutants in nature and making subtle changes in the production model.

1.2.2 Pollution prevention

Some companies take a proactive stance, doing more than simply controlling the damage done. Inspired by eco-efficiency standards, they radically change their processes, avoiding pollution before it is generated. Therefore, these organizations prefer to use more efficient materials and energy sources, promoting drastic reductions in the final amount of waste. Even so, it is still necessary to reconcile prevention and pollution control, because even so, the production leaves some leftovers that must be treated and discarded by the end of pipe control model. Despite this, prevention is very advantageous, as it reduces material, energy and waste expenses, significantly reducing waste treatment costs.

1.2.3 Strategic approach

This stage is reached when management realizes that sustainability can integrate the strategic planning of the company. That is, the organization learns to take commercial advantage by means of ecologically correct positioning (WACKERNAGEL & RESS, 1998).

1.3 Remediation Technologies

Environmental technologies can be defined as the set of knowledge, techniques, methods, processes, experiences and equipment that use the natural resources in a sustainable way and that allow the adequate disposal of industrial waste, so as not to damage the environment - also called environmentally sound technologies. They are obtained through environmental innovations, that is, the introduction of new technical and organizational behaviors, in the context of industrial production, which supports greater protection of the environment.

Technological development is one of the fundamental vectors that enables economic growth and is largely guided by the private interest in obtaining economic benefit in the short term. Both processes (economic growth and technological development) are intermittent, nonlinear, evolve over time and are characterized by temporal interdependence, in which both the history and its recent events and developments are important (MOREIRA, 1996).

Endowed of a reactive stance, some industries/companies only have remediation technologies, because they do not anticipate problems. Its ecological care is limited to correction, an environmental accident occurs, a procedure to reduce the damage is triggered.

However, there are situations where remediation techniques are in fact the best way out. This is the case, for example, of so-called no-till, used to combat soil degradation. This new practice keeps the straw and other remnants of the previous harvest on the land that will be planted, avoiding its wear. In addition, experts have recently discovered that no-tillage is capable of sequestering significant amounts of CO_2, the greenhouse gas. It is no coincidence that the Brazilian government strongly opposes this technique: the proposal made by the Brazilian delegation to the COP in Copenhagen foresaw the use of no-till to revitalize degraded pastures. Instead of deforesting, it is intended to recover these areas, becoming once again suitable for agriculture (SAVITZ, 2007).

A central problem, therefore, is to promote technological change in the control of cleaner technologies in order to achieve environmental sustainability, that is, natural resources be supplied to present and future generations, and that pollution levels be mitigated, even with the expansion of production. This is a complex problem, multidimensional, interdisciplinary and without a single answer. Moreover, technological change in the management of environmental sustainability depends on other non-economic factors, such as the development of firm-specific capabilities, infrastructure, and instructional changes.

There is some difficulty in associating the growth of industrial production with environmental preservation. Industrial pollution and the proportion of the use of natural resources are affected by the scale of industrial activity (scale effect), by its sectorial composition (composition effect) and by the technologies used (technology effect).

Thus, a country whose industrial production is concentrated in sectors that generate few environmental impacts but use technologies that are not environmentally friendly and that produce on a large scale can be considered an environmental degradation. Otherwise, a country that has an intensive industrial composition in sectors with high potential for pollution but adopts environmentally sound technologies, even large-scale production, may not be an environmental "villain". Therefore, the three effects mentioned above should be analyzed together to make an environmental diagnosis of the industry of a particular country or region. On the other hand, the competitive process of firms in economies generates a need for differentiation, inducing a process of innovation. By gaining mastery of a new technique in production or in a new product, the company begins to realize economic advantages, either in large profits or in the maintenance of its market share (MAY, 2010).

The modifications can be technical or organizational, the first refers to the introduction of a new method, product, system or equipment, ie is the creation of new technical principles. The second concerns changes in the organization system, in policies, in tasks, in procedures and in responsibilities - the introduction of new working and procedural practices with stakeholders. As environmental preservation became a factor of differentiation for the industries, thus characterizing itself as a business opportunity, it was possible to include environmental concerns in their business strategies by implementing an environmental management system, rationalization the use of natural resources, among other strategies (FIRJAN, 2002).

It is relevant to clarify the terms clean technology, environmental technology and technology that spares natural resources. The term environmental technology is more comprehensive, and is used to define technologies that are geared towards improving the environment, including cleaner technologies and the saving of natural resources and those that deplete the environment. Are they:

• Technologies to clean the environment (cleaning technologies): Are considered remediation. In general, these are end-of-pipe technologies, used after pollution has already occurred in chimney filters to reduce emissions of particulate matter;

• Environment-saving technologies: These are coefficients, because they use less inputs, are raw materials based on natural resources, or energy or as the recycling of water in industrial processes;

• Cleaner technologies: They are eco-efficient, since they present a coefficient of emission of pollutants per unit of product inferior to the other technology previously used, requiring changes in the productive processes. They can also be considered pollution prevention technologies;

• Control technology: Used to monitor emission levels and degradation of natural resources, such as satellites to identify deforestation and fires, and industrial emissions measurement equipment (KEMP, 1990);

• Membrane technology: It is an example of different branches of the industry for the selective selection of different compounds of an effluent. In recent years, a use of this technology has been amplified by a greater challenge regarding the concentration of some compounds in effluents discharged to natural reservoirs (DIETRICH, 1995).

The modern trend in industries is to analyze and care for waste at source and along the entire production chain, not just at the end of that chain, with the installation of filters. The smaller generation saves cost of transport and storage and with safety, protection and health of employees. The procedures for the reduction should include the activities of all those involved in the industries, including:

characterization of generated waste (types, chemical composition, quantities, generation points), modification of processes with incentives for the introduction of new technologies (cleaner) and promotion of strict quality control of the raw materials used with reference to the use of non-toxic materials and reduction of the use of hazardous materials (eg asbestos) (BAIRD, 2002).

Thus, Environmental Technologies have emerged as factors to help mitigate the environmental impacts caused by increased gas emissions, growth in waste generation and effluents launched by industries. In view of the problems caused by some kind of environmental impact, environmental technologies are in a position of great need in industries.

1.4 End-of-pipe technologies

It is different from Cleaner Production, because the relevant factor in this technology is to solve the causes of waste, without changing the production system, introducing technologies that capture the emissions of polluting gases or wastes in order to mitigate their environmental impact (LENZI, 2006).

This technology implants positives that hold the pollution before it is released in the wild. To do so, companies must use sophisticated equipment such as filters and treatment plants. In order to prevent their waste from spreading, some plants turn polluting gases and liquids into solid waste. But the solution is not so simple: the final disposal of these waste must follow the rules created by the competent environmental agency and depends on its approval. It is not a simple and cheap process; on the contrary, more expenses are added to the cost of production, and may even increase the final price of the merchandise.

Geffen (1995) uses the term "treatment or remediation technology" indicating the type of end of pipe. This technology is most often introduced to industries through environmental regulation, resulting in the transfer of pollution from one environment to another. Since the reach of this technology is limited and reduced, it does not eliminate the environmental pollution suffered by industries.

Because it is geared specifically to meet existing regulations, it does not always achieve a satisfactory result at the level of protection required, when there are changes to these regulations. In the long run, they become disproportionately costly to industry, compared to prevention technologies, because they increase the level of remediation measures, making it five times more expensive than prevention techniques (GEFFEN, 1995).

As long as there is efficient government regulation throughout the life of the industrial complex, remediation technologies will incur additional costs as a result of operations essential to pollution control and measures to address problems created by the pollutants they collect. An industrial process wastewater treatment plant results in sludge, which is a typical example of transfer of water pollution to soil pollution. If this sludge contains some Class I hazardous waste in accordance with NBR 10.004, 1987, it will continue to require provisions, which usually come to its final disposal under appropriate conditions. Thus, environmentally, whatever the response within a remediation approach or end of pipe will always have an unsatisfactory result, since there will be only one type of pollution replaced by another. For industries or companies this means that costs will have increases in production, which will hardly reduce in face of legal requirements. Such costs may increase as legal requirements become more stringent. The conclusion is that the broader technologies are in line with the proposals of the United Nations Development Program (UNDP) and Agenda 21, as they favor the economy of productive inputs and the reduction of waste and, therefore, the costs to the abstraction and final disposal.

1.4.1 Characterization of Tube End Technologies

Atmospheric emissions filters (Sleeve Technology), according to Pacheco, are very efficient equipment for this purpose, as well as being cost effective. It is a safe method of controlling emissions of pollutants, has a very high efficiency of collection, being able to collect large loads of particles resulting from the industrial processes of the most diverse segments.

In industrial sewage treatment plants, according to CETESB, water can be used in a variety of ways: machine washings, pipes and floors, the incorporation into the product, in the industrial process itself, in the cooling systems of steam generators and vessels toilets. In these cases, water does not need treatment only when it is incorporated into the products or evaporated.

1.5 Cleaner Production Technologies (P & L)

It is a technical strategy applied, economically and environmentally integrated to the productive processes. Its main objective is to increase the efficiency in the use of raw materials, energy and water through non-generation, mitigation or waste recycling and emissions. It is considered the environmental variable in all aspects of industries, taking as example the purchase of raw materials, design, after-sales, product engineering and environmental issues related to economic returns to industries. This technology has as a characteristic action that are implemented within the industries with the objective of being a more efficient operation, having more product generation and less waste. Through the implementation of the same, it can be concluded that it is the most appropriate technology for the production process.

In short, Cleaner Production eliminates pollution throughout the process, not end-of-pipe as well. The justification for this is the generation of waste from the industries that cost money, since they were purchased as raw material and there is consumption of inputs, such as water and energy. Due to the increase in the cost for the treatment and disposal of industrial waste, attempts to achieve an efficient result in relation to these liabilities have been a much-debated subject. Faced with this, mankind has depleted natural resources faster than its ability to replenish raw materials from the environment (PIRES, 2001).

Thus, in the 1990s, industries adopted proactive approaches to pollution prevention. Due to this need, the concept of Cleaner Production (P + L) was developed, an environmental management mechanism that aims to mitigate the impacts caused to the environment by assessing the causes of waste generation and modifying the processes that cause them (PIRES, 2011).

The United Nations Environment Program (UNEP) in 1989 proposed Cleaner Production and in 1990 gave it the following definition which is valid until today: "Cleaner production is the continuous implementation of an integrated and preventive environmental strategy, applied to processes, products and services to increase overall efficiency and reduce the risk to people of the environment" (UNEP, 1990).

Cleaner production is a mechanism for recognizing "where" and "why" an industry is losing resources in the mode of pollution and "how" can it mitigate those losses. It also deals with smaller amounts of pollution to be treated. In addition, it is not only limited to treating waste, but also incorporating it back into the process.

2 FIGURES

Technologies used for the mitigation, treatment and/or inertization of particulate, effluent and waste emissions. They are widely used in industries, being characterized as tube ends.

Figure 1 - Sleeve Filter

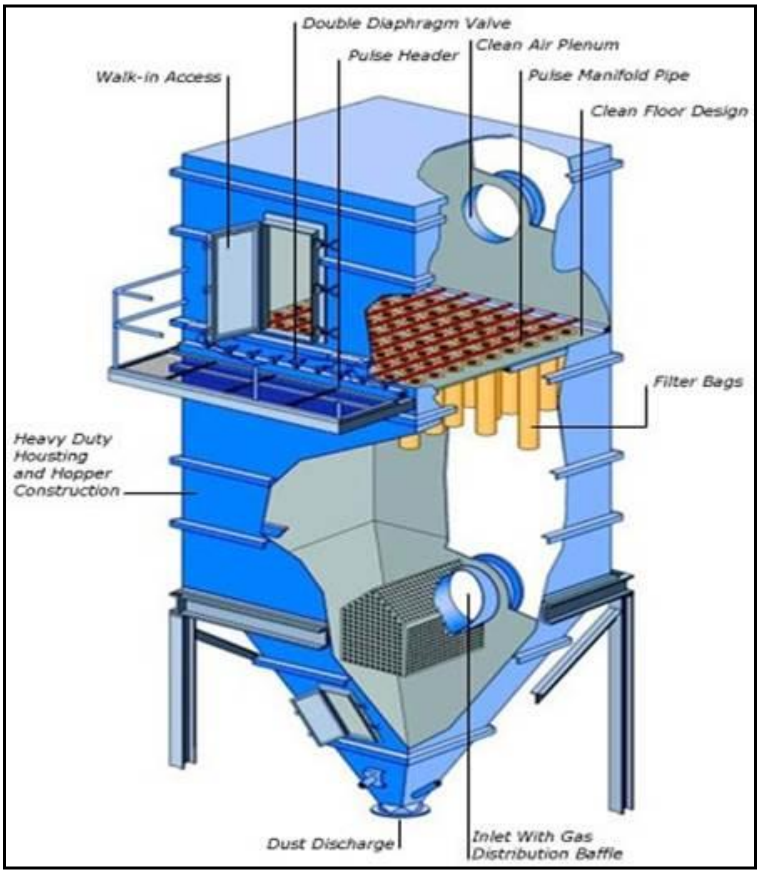
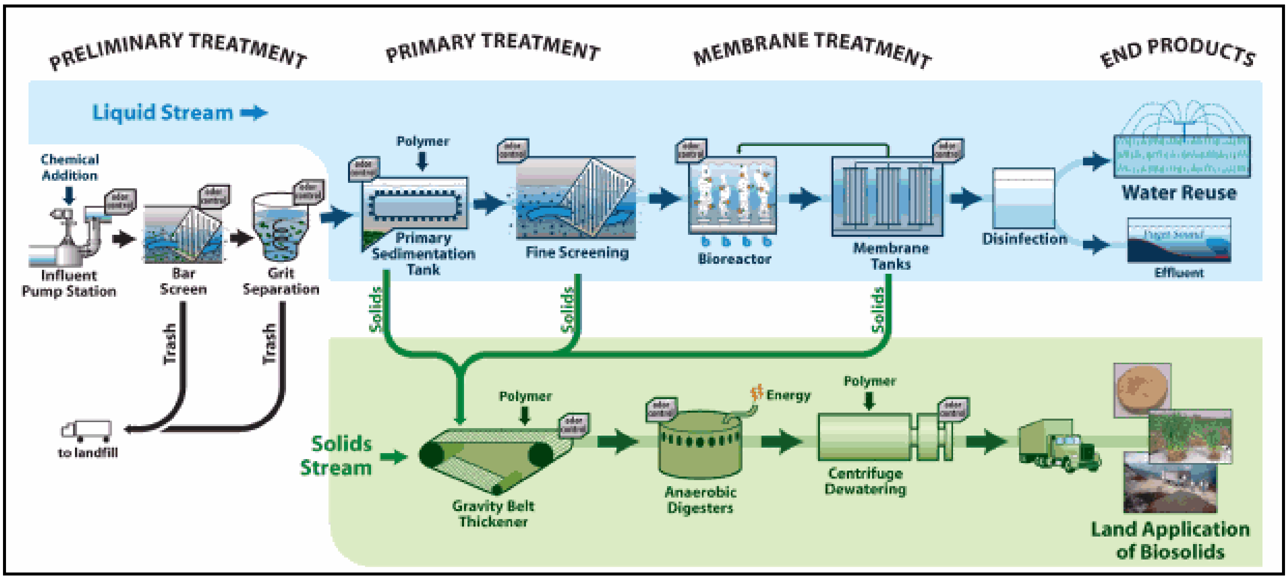


Figure 2 - Effluent Treatment Station



3 TABLE

Table 1 - End of pipe vs. Cleaner Production (P + L)

End of pipe	Cleaner Production (P + L)
Intends action	Intends action
Waste, effluent and emissions are controlled through treatment equipment.	Prevention of generation of waste, effluents and emissions at source. It seeks to avoid potentially toxic raw material.
Environmental protection is a matter for competent specialists.	Proteção ambiental é tarefa de todos.
Environmental protection operates after the development of processes and products.	Environmental protection acts as an integral part of the product and process engineering.
Environmental problems are solved from a technological point of view.	Environmental problems are solved at all levels and in all fields.
Do not worry about efficient use of raw materials, water and energy.	Efficient use of raw materials, water and energy.
It takes the additional costs.	Help reduce costs.

4 CITATIONS

The passage of specific laws for the environment has produced significant advances in public environmental policy in recent decades. However, according to Barbieri (2007), much remains to be done. Although extensive, Brazilian legislation is very much attached to the command and control instruments. Over and over, national policy is still focused on methods of monitoring and punishment, lacking initiatives to foster research and technological innovation. Unfortunately, the government has not yet learned how to influence the private sector in other ways - such as the less coercive incentive to develop non-aggressive technologies, or the promotion of rational use of natural resources. Although indispensable, the instruments of command and control can't be the only tools of public policy, as Barbieri explains:

> Command and control instruments are critical because they force companies to take action to control pollution, but they tend to induce a well-behaved behavior after compliance with legal requirements if they are not updated frequently (2007, p.107).

5 CONCLUSION

This theoretical revision started from the need to know the technologies of remediation, since many industries have learned that "to prevent" is better than to remedy. So, when problems happen, they turn to technologies that try to mitigate the consequences of the environmental accident. And for this, we have the remediation technologies, which are mechanisms that every decade has gained space, by which the demand of the industries has been increasingly intense.

The approval of Law No. 6.938/1981 was a great achievement for environmentalism in Brazil. It is a tool for the implementation of a remediation technology, since it covers procedures and the legal principles that sustain an environmental policy for the companies / industries, approaching in a systematic way the environmental problems.

Thus, it can be noticed that there was evolution of the end-of-pipe technologies and cleaner production. But each one with its distinction. We can observe that in order to pipe contains the pollution generated before it reaches the middle, using filters and even treatment plants, for example. However, besides being an expensive technology, it does not represent a definitive solution, because at the end of the process it adds waste treatment generated by the activity, increasing costs. Only for the purpose of complying with the legislation and the environmental control bodies.

Finally, it is concluded that technologies offer opportunities for a marked improvement in environmental quality, but they need to be cost effective for companies / industries and also have efficient strategies to mitigate or even combat environmental degradation. The technology most likely to meet these requirements is Cleaner Production technology, which aims to mitigate environmental impacts. By developing new products without waste and environmental impact, it is fundamental to implement the Cleaner Production technology, since it is an instrument that reaches the conditions proposed by the sustainable development process. However, it is not a practice used by many companies / industries, including Brazil. However, the application of this technology is of paramount importance in industries, since it optimizes the consumption of raw materials, energy and water, with reduction of operational costs; seeks economic solutions for waste reduction and non-generation of leftovers throughout the activities process, as highlighted by Henrique and Quelhas (2007). It is important to stress that cost-benefit in the process of implementing this technology is linked to the growth and development of the industry, together with the strengthening of the market. If the industries invest in the implantation of this technology of cleaner production, they will obtain the guarantee of the competitiveness and the improvement of the environmental quality.

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