A model for evaluating environmental impacts in gas stations

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Abstract
Purpose – The purpose of this paper is to set out a method for evaluating environmental impacts in the area of gas stations.

Design/methodology/approach – The design and implementation of this study followed steps that enabled a survey to be conducted by combining a wide variety of sources and bibliographical material, such as manuals, regulations, standards, laws and articles necessary for drawing up the model and the indicators of environmental impacts; and next the authors used two case studies to test the proposed model and exemplify the application.

Findings – This research identified the sources that cause adverse environmental impacts and the main preventive actions, as well as those for eliminating environmental impacts caused by the activities of the gas stations, so was possible developing a model which evaluated the real environmental situation of gas stations, using indicators to identify opportunities for improvements in the enterprises with ISO 14001 certification and non-certificated enterprises.

Research limitations/implications – This study used some international standards and some specific laws from Brazil, but it can be adapted to the current standards for gas stations in other countries.

Practical implications – Based on findings, it is believed that by using the model proposed in this research study, it is possible to diagnose the real environmental situation of the gas stations, thereby contributing to the preservation of the environment, sustainable development and above all to improving people’s quality of life.

Originality/value – The originality of this study is the development of a viable model that can be used by enterprise, researchers and governmental environmental agencies for evaluating the environmental impacts of gas stations, integrating four different variables.

Keywords Brazil, Health and safety requirements, Contaminants, Gas stations, Filling stations, Garages (commercial), ISO 14001:2004 Standard, Environmental impacts

Paper type Research paper

1. Introduction
With the evolution of ecological awareness and the concern of governments and the public about the relationship between economic development and the environment, attitudes are being rethought, since what should be implemented is thinking on sustainable development so as to ensure quality of life, economic growth and most of all, survival.

The authors are grateful for the support received to carry out this study from the National Council for Scientific and Technological Development (CNPq), the Brazilian governmental entity which promotes scientific and technological development.
In the last years, environmental problems started to motivate the emergence of a new ecological vision of society. It was becoming an increasingly prominent focus of international and national policy making to ease everyday life and comprehend the effects on society, the economy and the ecology (Sebhatu and Enquist, 2007). Moreover, the adverse environmental impacts caused by human activities whether in industries, or in commerce or in any other activities, modify the environment directly or indirectly. When it comes to adverse environmental impacts caused by the activities of service station (or gas station), the topic that is the focus of this study, the risks to and effects on the environment and people are significant.

Scientific studies on this subject are rather limited, being restricted in practice to the activities of the CPRH (Pernambuco company for the environment) and the importance that the oil sector together with fuel distribution depots have for Brazil’s economy. This is specifically the case for the State of Pernambuco and for the quality of life and conservation of nature. Therefore, this study is justified because it should prompt further scientific studies in this area. It is also hoped that it will be seen as a contribution to various environmental agencies in their constant struggle to reduce this kind of environmental impact, and thus help to improve life in society at large and to preserve the environment, by ensuring that future generations can enjoy nature as it still does as present. The study therefore sets out a method for evaluating environmental impacts in the area of gas service station.

During the review of the literature, scientific papers were found that tackle issues related to gas station. However, they were specific to certain areas of study like, for example, articles on occupational health and medicine and in the area of soil and groundwater (Gomes, 1981; Gattás et al., 2001; Keiloun et al., 2002), and so forth. We found other studies that show models for evaluating environmental impacts (Fehr, 1999; Azevedo and Bias, 2011), but these works not follow an approach about impacts caused by the activities of gas station.

In literature, we neither found any study about an integrated approach to adverse environmental impacts caused by the activities of gas station, nor an approach to assess some impacts caused by it.

Therefore, the need emerged for an integrated approach to adverse environmental impacts caused by the activities of gas station, what factors contribute to or influence such impacts and the major preventive actions and/or ways of remedying them. These issues have become our purpose in this research.

The paper is structured in six sections to present the development of the model for evaluating environmental impacts:

1. Introduction;
2. Background;
3. Methodology;
4. Model for evaluating environmental impacts;
5. Practical application of the model developed: case study; and
6. Conclusion.

2. Background
According to scientific studies conducted by some authors: Gomes (1981), Mello and Cavalcante (1992) and Gattás et al. (2001), workers in gas station, subject to chronic
exposure, suffer from several effects: irritation in their eyes and on their skin, dermatitis, leukemia, genetic mutations, and so forth. According to Araújo (2003), the human exposure pathways of infection are: via the skin, i.e. cutaneous ones; via the respiratory system, through inhalation of the vapors from the fuels and gases emitted by vehicles; and via the digestive system, through the consumption of contaminated water coming from supply wells.

In his study, Gomes (1981) conducted a survey of the diseases presented by gas station employees in different functions, such as: in the actual filling up of vehicles (pump attendants), washing, cleaning, lubrification, oil changes, etc. and, proved that the vast majority of lesions are on the skin. What were identified were: dermatitis, conjunctivitis, eye-watering, elaiocconiosis, interdigital dermatomycosis and onychomycosis, keratosis and hyperkeratosis due to these workers being directly and indirectly exposed to the products of the stations, such as fuel and its fumes, lubricating oils, detergents, etc.

Mello and Cavalcante (1992) conducted a scientific study on gas station attendants, which showed a significant increase in chromosome deletion. Similarly Hallare et al. (2009) also, on conducting a study involving the health of gasoline station (or gas station) attendants and traffic wardens in the city of Manila in the Philippines, stressed the importance of their using some form of protective wear such as a mask in their work environments. Keiloun et al. (2002) evaluated the exposure of service station attendants with regard to methylcyclopentadienyl manganese tricarbonyl in Canada.

The contamination of the soil and consequently of groundwater is one of the major environmental impacts caused by the activities of service stations, since this is related to health problems, environmental damage and adverse social impacts. There are several sources of groundwater contamination. However, one of the most hazardous is contamination through leaks in underground storage tanks of fuel, the severity of which increases due to the characteristics of the fuels being rich in toxic substances of a mutagenic and carcinogenic character, and to the great likelihood of movement in the soil, and the fact that a leak is not always detected immediately. Indeed, this may even take a long time and therefore shed many liters of fuel into the soil (Cordazzo et al., 2002).

In accordance with CONOMA (2009), (the Brazilian National Council for the Environment – Conselho Nacional do Meio Ambiente, in portuguese) Resolution 273, dated 29 November 2000, gas station should follow Brazilian Standard NBR 13786:2005 dealing with the “Selection of equipment and systems for underground fuel facilities” so as to avoid prevent possible leaks from these systems into the soil and especially from underground fuel storage tanks. It is extremely important to control the useful life of the tank, which according to Corseuil and Martins (1997), is approximately 25 years.

According to Cordazzo et al. (2002), gasoline, the main contaminant dealt with in this study, when it enters contact with groundwater, it partially dissolves and releases the constituents: benzene, toluene, ethylbenzene and xylenes called BTEX which represent the most soluble and mobile compounds found in gasoline (Poulsen et al., 1992).

One of the environmental impacts caused by the activities of gas station are the effects caused by fires, which, when they occur, are very harmful to employees, customers, owners, and the neighborhood and may cause fatalities. According to Means et al. (1980), the incomplete combustion of some materials such as: gas, coal, oil and wood are a natural or anthropogenic source of aliphatic hydrocarbons and polycyclic aromatic hydrocarbons, which can cause people to be contaminated.
Given these dangers, some precautions must be taken in the handling of petroleum products in order to prevent fire and risks to people. Some of the parameters in the model were developed after consulting the operations manual of health safety security environment (HSSE) for service station – Shell Brazil LTDA (2003) and the Atlas (2003) Manual of Legislation: Occupational Safety and Medicine, the characteristics of a fire, methods for extinguishing and preventing them, specifically for service station.

Another type of environmental impact that may occur arising from the activities of service station is the impact caused by their respective wastes. The Brazilian Regulatory Norm (NBR) 10004:2004 dealing with “solid waste”, among other things, classifies solid wastes with regard to potential risks to the environment and people’s health, and shows what types of waste need to be most rigorously handled and have a more strictly controlled final destination, as is the case of waste generated by gas service station, as follows: wastes Class I – hazardous; wastes Class II – non-inert; wastes Class III – inert.

According to the Shell Operations Manual HSSE to Gas Service Station – Shell Brazil LTDA (2003), some pre-cautions should be taken as to areas for the storage and proper storage of hazardous solid waste and/or semi-solid waste and these apply to service stations. Thus, it is important for great care to be taken with: the characteristics of the storage area of the containers containing hazardous waste; the disposal of hazardous solid waste; the types of hazardous waste generated in the service stations, etc.

For to build the model for evaluating environmental impacts, the study is based on evidence provided by a set of documents as: regulations, norms, standards, manuals, etc. as well as articles and research reports.

2.1 The sector studied

2.1.1 Refining. The effective installed refining capacity worldwide in 2008 was 88.6 million barrels per day, for a world-wide production of oil of 81.8 million barrels per day. The USA maintained first place in the ranking (20 percent of total), followed thereafter by China (8.7 percent), Russia (6.3 percent), Japan (5.2 percent) and India (3.4 percent). Together, these countries represent 43.5 percent of the global oil-refining capacity. Compared with 2007, this share has remained constant. Brazil reached thirteenth place in the world ranking of global refining capacity, one place up from the position achieved in 2007. Its capacity was 1.9 million barrels per day in 2008, equivalent to 2.2 percent of world capacity (ANP, 2009).

It is thus seen how important the oil sector is to the world, and, consequently, for the social, economic and environmental development of Brazil.

2.1.2 Gasoline service stations. In late 2006, 34,709 service stations were operating in Brazil, a figure 2.4 percent lower than in 2005, and at the end of 2008, 36,730 gas stations were operating in the country, 4.9 percent higher than the number of service stations noted in the previous year. Of the total number of service stations in 2008, 42.3 percent were in the southeast region, 21.2 percent in the south region, 21.3 percent in the northeast region, 8.8 percent in the center-west region and 6.5 percent in the north region. That is to say, 84.8 percent of petrol service stations were located in the southeast, south and northeast (ANP, 2009).

3. Methodology

The main aim of this work is to set out a method for evaluating environmental impacts in the area of gas station, because in literature there is no a model which integrate the impacts about the four main perspectives proposed on this work.
Thus, the design and implementation of this study followed steps that enabled a survey to be conducted by combining a wide variety of sources and bibliographical material, such as laws, manuals, regulations, articles and standards necessary for drawing up the model and the indicators of environmental impacts. First, an extensive review of the literature was carried out, involving books, journals, operating manuals and technical standards, for find what and how much are the main perspectives about environmental impacts in gas station, and thus, we found secondary data. In the second step, a review of the literature was prepared and thereafter, a model for assessing environmental impacts in the oil sector, targeting gas station and based on indicators.

The third stage involved the completion of two case studies in the metropolitan area of greater Recife, to test the model and exemplify the application (Eisenhardt, 1989; Eisenhardt and Graebner, 2007), which are:

(1) a gas station with an environmental management system (EMS) that meets the requirements of ISO 14001:2004; and

(2) another gas station which is not certified as meeting the requirements of this ISO in both of which questionnaires were applied to the owner, the manager and staff.

The last step involved analyzing the data obtained.

In order to design the model, the study had to:

- study the existing legislation (in Brazil, Pernambuco and Recife) related to environmental protection in the fuel distribution sector;
- examine the processes and methods used in identifying and assessing environmental impacts in general and the environmental impacts caused by gas station;
- examine the methods used to reduce and/or eliminate environmental impacts caused by gas station;
- study the standards of the ISO 14000 series and their application to gas station; and
- propose a set of indicators for assessing environmental impacts in gas station in order to assist them with ISO 14001:2004.

4. Model for evaluating environmental impacts

Based on the papers presented in the review of the literature, the research undertaken analyzes the adverse environmental impacts caused by the activities of service station, in the oil sector, under four perspectives: human contamination; contamination of soils and groundwater; risk of fire and hazardous solid waste, since the risks arising and their impacts on the environment and society are very significant. Yet, nowhere in the literature are there any studies that encompass such aspects in an integrated manner.

Therefore, this paper proposes a model for assessing environmental impacts in the oil sector, focused on gasoline gas stations in Greater Recife and checks the implementation of this model for a gas station with an EMS which has ISO 14001:2004 certification and another that is not certificated.

The proposed model assesses the environmental impacts targeted on gas stations, so as to evaluate the application of the model for helping gas stations with an EMS and ISO 14001:2004 certification to verify if they have achieved continuous improvement at the time of their self-evaluation and also to help non-certificated depots in their quest for certification.
For this, the model was compiled from indicators with the aim of assessing the risks and/or potential environmental impacts of the activities of gas stations, from the perspective of four categories formulated from the approaches perceived in the review of the literature: human contamination, soil contamination, fire hazards and hazardous solid waste generated. The indicators are proposed taking into consideration the adverse environmental impacts caused by gasoline that in its chemical composition has toxic components, these components giving gasoline the potential to cause environmental impacts in gas stations.

Figure 1 shows the model for evaluating the environmental impacts of gas stations, proposed in this paper.

4.1 Indicators for evaluating environmental impacts
The indicators will be presented later in tables according to the following structure: in the first column, there are the categories considered in this paper; in the second are the indicators as per the nomenclature adopted; in the third column are the elements that refer to the context, situation, subject or nature that characterizes each indicator; in the third are the factors that define the basic components to be considered in the evaluation mechanism; in the fourth column are the units of measurement of the factors; in the fifth column, the standard is described for each indicator that is the reference used.
to verify the real situation of the process under analysis; and in the sixth column the
result which would be expressed should the model be used in an evaluation.

The indicators presented were defined based on legal requirements, such as: on the
requirements of CONAMA Resolution 273, on the requirements of the bodies involved
in environmental issues for gas stations, which in Pernambuco is CPRH, on scientific
papers in the research area of this study and on a *Shell Operations Manual* (2003) that
was considered a “benchmark”.

These indicators were divided into four groups A, B, C and D, which represents the
categories, namely:

1. evaluation indicators of human contamination;
2. indicators for assessing contamination of the soil and groundwater;
3. indicators for evaluating the risks of fire; and
4. indicators for assessing the adverse environmental impacts caused by
hazardous solid waste generated in the gas service stations.

In the board presented in Table I, the indicators of the human contamination category
(A) by means of their nomenclatures, are presented, as well as the factors, measures for
assessment and the standard of reference for each indicator.

For category A, which assesses human contamination, the following indicators
were identified from the literature for legal standards and laws, interviews and
consultancies, the following indicators:

A.1 – Completing the Environment Risk Prevention Programs – Programa de
Prevenção e Riscos Ambientais (PPRA) – in portuguese, presented
in NR-7).
A.2 – Completing the occupational health monitoring programs (OHMP).
A.3 – Use of personal protective equipment (PPE).
A.4 – Proper use of PPE.
A.5 – Level of hygiene education.
A.6 – Conducting training.
A.7 – Filing of documents.
A.8 – Period of archiving documents.

In Table II, the indicators are presented of the category of the contamination of the soil
and groundwater (B) through their nomenclatures, as well as the factors, measures for
assessment and the reference standard for each indicator.

For category B, which evaluates the contamination of the soil and groundwater, the
following indicators were defined from the literature and legal rules in force and
CONOMA resolutions, the *Shell Operations Manual*, interviews and consultancy:

B.1 – Compliance with CONAMA Resolution 273.
B.2 – Operating license (OL) of the competent environmental agency.
B.3 – Check the expiry date of the operation license.
B.4 – Filing of documents.
B.5 – Environmental monitoring.
### Table I.
Indicators for evaluating human contamination

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
<th>Element</th>
<th>Factor</th>
<th>Measure</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human contamination (A)</td>
<td>PPR (A1)</td>
<td>Poor (does not conduct PPRA), satisfactory (meets the evaluation of the risks and the exposure of staff and implements the measures for controlling and evaluating its effectiveness), good (meets all the obligatory steps), excellent (meets all the obligatory steps and meets one or more of the steps recommended in NR-7)</td>
<td></td>
<td>MEQ</td>
<td>22.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>Poor (does not conduct PCMSO), satisfactory (meets only the admittance test), good (meets all the obligatory tests), excellent (meets all the obligatory exams and the non-obligatory ones)</td>
<td></td>
<td>MEQ</td>
<td>8.10</td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
<th>Element</th>
<th>Factor</th>
<th>Measure</th>
<th>Standard</th>
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</tr>
</thead>
<tbody>
<tr>
<td>A5</td>
<td>Hygiene education</td>
<td>Check through survey with staff the level of hygiene education: poor, satisfactory and good</td>
<td>Poor (they do not know what hygiene is), satisfactory (has a shower before coming to work and on going back home), good (they take a shower before coming to work and on returning home, they wash their uniforms, they wash their hands before meals and snacks)</td>
<td>Interview with the employee on being hired</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A6</td>
<td>Training</td>
<td>Check that training has been carried out on hygiene and subjects on occupational health</td>
<td>Is or is not carried out</td>
<td>Hiring a consultancy or specialist in the occupational health area targeted on service stations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A7</td>
<td>Filing of documents</td>
<td>Check the filing of documents on occupational health</td>
<td>Documents filed or not</td>
<td>NR-7 and NR-9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A8</td>
<td>Period of archiving documents</td>
<td>Check control of the time of filing</td>
<td>PPRA minimum period 20 years and PCMSO minimum period 20 years from the day the staff member leaves</td>
<td>NR-7 and NR-9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** The authors (2011)
<table>
<thead>
<tr>
<th>Category</th>
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<th>Measure</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>CONAMA Resolution 273</td>
<td>Check the percentage fulfilment of CONAMA Resolution 273</td>
<td>Percentage meeting requirements (%)</td>
<td></td>
<td>CONAMA Resolution 273</td>
<td></td>
</tr>
<tr>
<td>B2</td>
<td>OL</td>
<td>Check there is an OL</td>
<td>Does or does not have one Licence within expiry date or passed the expiry date</td>
<td></td>
<td>CONAMA Resolution 273</td>
<td></td>
</tr>
<tr>
<td>B3</td>
<td>Expiry date</td>
<td>Check if the operating licence is within its expiry date</td>
<td>Licence within expiry date or passed the expiry date</td>
<td></td>
<td>CPRH</td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>Filing of documents</td>
<td>Check legally required documents are filed</td>
<td>Documents are filed or not</td>
<td></td>
<td>CONAMA Resolution 273 and CPRH</td>
<td></td>
</tr>
<tr>
<td>B5</td>
<td>Environmental monitoring</td>
<td>Check by questionnaire with the owner of the service station if he conducts environmental monitoring by collecting samples of water from wells, of tank leak tests, of control of the book of the movement of fuel and others the occurrence of contamination of the soil and groundwater and measure by scale: poor, satisfactory, good and excellent</td>
<td>Poor (does not conduct any environmental monitoring), satisfactory (only conducts control of the book for monitoring fuels), good (conducts monitoring in the wells for capturing water for use in the service station, in the monitoring wells, controls the book of movement of fuels) and excellent (conducts all the previous activities and other ones)</td>
<td></td>
<td>CONAMA Resolution 273 and CPRH</td>
<td></td>
</tr>
<tr>
<td>B6</td>
<td>Operational procedures</td>
<td>Check if there are operational procedures</td>
<td>Operational procedures exist or they do not</td>
<td></td>
<td>Scientific papers, manufacturers’ manuals, suggestions from environmental bodies or hiring consultants specialized in the subject</td>
<td></td>
</tr>
<tr>
<td>B7</td>
<td>Staff’s level of information</td>
<td>Check through a questionnaire staff's level of information on the maintenance and operation of equipment of service stations, risks of environmental impacts and emergency actions in case of environmental accident by a scale: poor, weak, good and excellent</td>
<td>Poor (they only know about operation), good (they know about operation, maintenance, and some environmental impacts) and excellent (they know about operation, maintenance, the risks which involve the contamination of the soil and and what should be done, should an environmental accident be detected)</td>
<td></td>
<td>Shell Operations Manual and scientific papers</td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Category</th>
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<th>Measure</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>B8</td>
<td>Level of information of the owner of the filing station</td>
<td></td>
<td>Check the owner of the service station's knowledge on his environmental responsibilities due to legislation</td>
<td>Does or does not know the environmental responsibilities required by norm</td>
<td>CONAMA Resolution 273</td>
<td></td>
</tr>
<tr>
<td>B9</td>
<td>Training</td>
<td></td>
<td>Check training events are held on the operation and maintenance of equipments and the main preventative actions and for remedying the contamination of the soil and groundwater</td>
<td>Is or is not held</td>
<td>Hiring of consultancy or specialist in the area of service stations</td>
<td></td>
</tr>
<tr>
<td>B10</td>
<td>Supervisory system for leakages</td>
<td></td>
<td>Check if a supervisory system for fuel leakages in underground storage tanks has been set up</td>
<td>Does or does not have a supervisory system setup</td>
<td>Hiring specialized company</td>
<td></td>
</tr>
<tr>
<td>B11</td>
<td>Register of companies specializing in treating contamination of the soil and groundwater</td>
<td></td>
<td>Check if the service station has a record of companies authorized and specialized in treating the contamination of the soil and groundwater</td>
<td>Does or does not have a register</td>
<td>CPRH</td>
<td></td>
</tr>
<tr>
<td>B12</td>
<td>Documentation of the contaminations occurred and remedial actions adopted</td>
<td></td>
<td>Check if there is documentation on the environmental liabilities of the service station</td>
<td>Does or does not have documentation</td>
<td>CONAMA Resolution 273</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** The authors (2011)
B.6 – Realization of operational procedures.
B.7 – Level of employees’ information about the operation, maintenance and emergency actions.
B.8 – Level of information of the owners of the stations about their environmental responsibilities.
B.9 – Conducting training.
B.10 – Installation of a supervisory system for leaks.
B.11 – Register of companies specializing in treating contaminated soil and groundwater.
B.12 – Documentation of contamination events that occurred and remedial action taken.

Table III presents the indicators of the fire risk category (C) through their nomenclatures, as well as the factors, measures for assessment and reference standard for each indicator.

For category C, which assesses the risks of fire, the following indicators were identified from the literature and legal rules and COMOMA resolutions, The Shell Operations Manual, interviews and consultancies:

C.1 – Certificate of regularity from the fire brigade (CR).
C.2 – Control of the validity of certificate of regularity.
C.3 – Check the expiry dates of extinguishers.
C.4 – Emergency plan.
C.5 – Operational procedures.
C.6 – Proper use of PPE.
C.7 – Type of appropriate fire extinguisher.
C.8 – Use warning signs.
C.9 – Conducting training.
C.10 – Organization of documents.

Table IV presents the indicators of the category of hazardous solid waste (D) through their classifications, as well as factors, measures for assessment and standard of reference for each indicator.

For category D, which assesses the environmental impacts caused by hazardous solid waste generated in the gas stations, the following indicators were defined from the literature and legal rules and CONOMA resolutions, the Shell Operations Manual, interviews and consultancies:

D.1 – Enforcement of final disposal of hazardous solid waste.
D.2 – Use of PPE.
D.3 – Proper use of PPE.
D.4 – Terms of waste storage.
D.5 – Containers for storage of waste suitable.
D.6 – Storage area of storage containers of hazardous solid waste.
<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
<th>Element</th>
<th>Factor</th>
<th>Measure</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riscos de Incêndio (C)</td>
<td>C1</td>
<td>Certificate attesting to regularity</td>
<td>Check if the service station has the certificate attesting to regularity issued by the FB of Pernambuco</td>
<td>Does or does not have the CR</td>
<td>CONAMA Resolution 273 and CPRH</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>Expiry date of certificate attesting to regularity</td>
<td>Check if the expiry date of the certificate attesting to regularity conforms to the requirements</td>
<td>Is within the expiry date or is past the expiry date</td>
<td>FB of Pernambuco</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>Expiry dates of fire extinguishers</td>
<td>Check the expiry dates of the fire extinguishers in the service station</td>
<td>Percentage of extinguishers beyond the expiry date</td>
<td>Pernambuco FB and companies manufacturing extinguishers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>Emergency plan</td>
<td>Check there is an emergency plan in the service station</td>
<td>Does or does not have an emergency plan</td>
<td>Recommendations of PPRA and the Pernambuco FB</td>
<td>Shell Operations Manual</td>
</tr>
<tr>
<td></td>
<td>C5</td>
<td>Operational procedures</td>
<td>Check there are operational procedures on security measures for fires in service stations</td>
<td>Does or does not have safety procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C6</td>
<td>PPEs</td>
<td>Check the correct use of the PPEs by observation and questionnaire with the staff of service stations</td>
<td>Correct or incorrect use</td>
<td>NR-06, recommendations of PPRA and PCMSO and Shell Operations Manual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C7</td>
<td>Signs warning of danger</td>
<td>Check the use of signs on the risks of fires by untoward acts and restrictions as to the use of electronic appliances</td>
<td>Does or does not have warning signs</td>
<td>FB and Shell Operations Manual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C8</td>
<td>Training</td>
<td>Holding training events on operational procedures for conducting their activities, preventative and emergency actions on fire risks</td>
<td>Does or does not mount training events</td>
<td>Hiring people specialized in the subject or consultants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C9</td>
<td>Documents</td>
<td>Check if documents referring to fires required by the FB service of Pernambuco and CPRH are filed</td>
<td>Does or does not have a file of such documents</td>
<td>CONAMA Resolution 273 and requirements of the competent environmental body and of the FB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C10</td>
<td>Electrical installations</td>
<td>Check the type of electrical installation in the places at risk from fires</td>
<td>Fulfilment of NBR 14639 (explosion proof electrical fittings)</td>
<td>NBR 14639</td>
<td></td>
</tr>
</tbody>
</table>

Note: The Brazilian Regulatory Norm (NBR) 14639 – Service station – Electrical installation

Source: The authors (2011)
Table IV. Indicators for evaluating hazardous solid waste

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
<th>Element</th>
<th>Factor</th>
<th>Measure</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resíduos Sólidos Perigosos (D)</td>
<td>D1</td>
<td>Disposal of hazardous solid waste</td>
<td>Check by questionnaire the percentage to which guidelines for the final disposal of hazardous solid waste are met</td>
<td>Percentage of meeting guidelines</td>
<td>Shell Operations Manual and requirements of the competent environmental body</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D2</td>
<td>PPE</td>
<td>Check use of PPE by staff</td>
<td>Does or does not use them</td>
<td>NR-6, PPRA, PCMSO and scientific papers published</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D3</td>
<td>PPEI</td>
<td>Check correct use of of PPEs by staff is in accordance with their respective activities</td>
<td>Correct or incorrect use</td>
<td>NR-6, PPRA, PCMSO and scientific papers published</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D4</td>
<td>Storage conditions of the waste</td>
<td>Check by observation and questionnaire the percentage to which guidelines for the storage of hazardous solid waste are met</td>
<td>Percentage of meeting guidelines</td>
<td>Shell Operations Manual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D5</td>
<td>Recipients for storage of waste</td>
<td>Check by observation and questionnaire if the recipients used for storage are adequate as per the guidelines of the Shell Operations Manual</td>
<td>Percentage of meeting guidelines</td>
<td>Shell Operations Manual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D6</td>
<td>Area for storing the recipients containing hazardous solid waste</td>
<td>Check by observation and questionnaire if the area reserved for storing recipients containing solid waste is adequate as per the Shell Operations Manual</td>
<td>Percentage of meeting guidelines</td>
<td>Shell Operations Manual</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
<th>Element</th>
<th>Factor</th>
<th>Measure</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>D7</td>
<td>Operational procedures</td>
<td>Check if there are operational procedures on the handling, storage and final destination of the hazardous solid waste generated by the activities of service stations</td>
<td>Does or does not have procedures</td>
<td></td>
<td>Shell Operations Manual</td>
<td></td>
</tr>
<tr>
<td>D8</td>
<td>Training</td>
<td>Training events held on operational procedures for the handling, storage and hazardous solid waste generated by the activities of service stations</td>
<td>Does or does not hold training events</td>
<td></td>
<td>Hiring specialists in the subject or consultants</td>
<td></td>
</tr>
<tr>
<td>D9</td>
<td>Documents</td>
<td>Check if there is a file of the documents referring to the final hazardous solid waste generated by the activities of service stations</td>
<td>Does or does not have a file of such documents</td>
<td>Requirements of the competent environmental body and of the FB and Shell Operations Manual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D10</td>
<td>Control of the period of filing documents of final destination</td>
<td>Check by questionnaire if there is control of the period of archiving documents referring to hazardous solid waste generated by the activities of service stations</td>
<td>There is control or there is not control of the period of filing documents (recommended period 20 years)</td>
<td>Shell Operations Manual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D11</td>
<td>Register of companies specializing in final destination of hazardous solid waste</td>
<td>Check if the service station has a register of the companies authorized and specialized in hazardous solid waste</td>
<td>Does or does not have the register</td>
<td>CPRH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
<th>Element</th>
<th>Factor</th>
<th>Measure</th>
<th>Standard</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>D12</td>
<td>Inspection on the premises of the company hired to make the final destination of the hazardous solid waste</td>
<td>Check if visits are made to the facilities of the company to be contracted that will find the final destination of the hazardous solid waste generated by the activities of service stations</td>
<td>Does or does not receive inspection visits</td>
<td>Shell Operations Manual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D13</td>
<td>Control of the expiry date of licences and documents</td>
<td>Check by questionnaire and observation if there is control of the expiry dates of the licences and documents required by CPRH</td>
<td>Undertakes control of expiry dates or does not do so</td>
<td>CONAMA Resolution 273, deadlines set by CPRH and Shell Operations Manual</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: The authors (2011)
D.7 – Operational procedures.
D.8 – Conducting training.
D.9 – Organization of documents allocation of hazardous solid waste.
D.10 – Period for filing of documents for disposal.
D.11 – Registration of companies specializing in transporting and disposing of hazardous solid waste.
D.12 – Control of the validity of proper permits and requirements of the competent environmental agency.

5. Practical application of the model developed: case study
These practical applications are designed to assess the feasibility of the proposed model in both types of gas station as well as the potential environmental impacts of the gas stations selected, using the model as a tool for evaluating environmental impacts through the indicators proposed in this study, so as to identify opportunities for improvement for Gas Station Case Study 1 (gas station certificated by standard ISO 14001) and the guidelines that will help Gas Station Case Study 2 (gas station not certified by standard ISO 14001) to obtain ISO 14001 certification.

5.1 Case study 1
For the object of this first application of the proposed model, a gasoline station was chosen that has been certified by the standard of ISO 14001 since 1999. This gas station has five supply pumps with six nozzles each, and a supply pump with four nozzles, nine underground fuel storage tanks with six years of use and to maintain confidentiality, it will be deemed: Gas Station Case Study 1.

The results obtained for Gas Station Case Study 1 after the interviews with the owner, the manager of the gas station and the staff will be presented for each indicator in Table V.

Therefore, as per the model for evaluating the environmental impacts that target gas stations, Gas Station Case Study 1 can be considered in accordance with legal requirements and is not a cause or potential cause of adverse environmental impacts analyzed under the approaches discussed in this study.

5.2 Case study 2
The so-deemed Gas Station Case Study 2, another object of this case study chosen is not certificated with ISO 14000. This gas station has four pumps with two nozzles each, three underground fuel storage tanks with five years of use and for confidentiality reasons, its name and address will not be disclosed.

The results for Gas Station Case Study 2 after conducting interviews with the owner or manager of the gas station and with the staff will be presented for each indicator in Table VI.

Therefore, as per the model for evaluating the environmental impact that target gas stations, the Gas Station Case Study 2 can be considered a potential cause of adverse environmental impacts analyzed under the approaches discussed in this study because it does not comply with various guidelines suggested by this model.

5.3 Discussion about these two case studies
Given this scenario, although the Gas Station Case Study 1 does not show signs of posing risks to the environment, some opportunities for improvement were identified
### Gas station case study

<table>
<thead>
<tr>
<th>Human contamination (A)</th>
<th>Contamination of the soil and groundwater (B)</th>
<th>Risk of fire (C)</th>
<th>Hazardous solid waste (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 First class</td>
<td>B1 100 percent of the items selected</td>
<td>C1 Has CR</td>
<td>D1 Meets 87.5 percent of the guidelines</td>
</tr>
<tr>
<td>A2 Excellent</td>
<td>B2 Holds one</td>
<td>C2 Document within expiry date</td>
<td>D2 Uses it</td>
</tr>
<tr>
<td>A3 Uses it</td>
<td>B3 Licence within expiry date</td>
<td>C3 100 percent of the extinguishers are within expiry date</td>
<td>D3 Uses it correctly</td>
</tr>
<tr>
<td>A4 Uses it correctly</td>
<td>B4 Has a file of the documents</td>
<td>C4 Has an emergency plan</td>
<td>D4 Meets 100 percent of the guidelines</td>
</tr>
<tr>
<td>A5 Good</td>
<td>B5 First class</td>
<td>C5 Has security procedures</td>
<td>D5 Meets 100 percent of the guidelines</td>
</tr>
<tr>
<td>A6 Conducts them</td>
<td>B6 There are operational procedures</td>
<td>C6 Correct use</td>
<td>D6 Meets 100 percent of the guidelines</td>
</tr>
<tr>
<td>A7 Has a file</td>
<td>B7 Good</td>
<td>C7 Has warning signs</td>
<td>D7 Has procedures</td>
</tr>
<tr>
<td>A8 Period of archiving controlled</td>
<td>B8 Knows about this</td>
<td>C8 Performs treatment</td>
<td>D8 Performs it</td>
</tr>
<tr>
<td>B9 Performs it</td>
<td></td>
<td>C9 Has a file of documents</td>
<td>D9 Has files of documents referring to the final destination of hazardous solid waste</td>
</tr>
<tr>
<td>B10 Has a supervisory system</td>
<td></td>
<td>C10 Meets NBR 14639</td>
<td>D10 There is control of the archiving of documents</td>
</tr>
<tr>
<td>B11 Has a register</td>
<td></td>
<td></td>
<td>D11 Has a register</td>
</tr>
<tr>
<td>B12 Adverse environmental impacts have never been detected</td>
<td></td>
<td></td>
<td>D12 Does not make visits to the facilities of the company contracted</td>
</tr>
</tbody>
</table>

**Source:** The authors (2011)
## Gas station case study 2

<table>
<thead>
<tr>
<th>Human contamination (A)</th>
<th>Contamination of the soil and groundwater (B)</th>
<th>Risk of fire (C)</th>
<th>Hazardous solid waste (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indic.</td>
<td>Result</td>
<td>Indic.</td>
<td>Result</td>
</tr>
<tr>
<td>A1 Satisfactory</td>
<td>B1 57.14 percent of the items selected</td>
<td>C1 Has CR</td>
<td>D1 Meets 12.5 percent of the guidelines</td>
</tr>
<tr>
<td>A2 Good</td>
<td>B2 Has one</td>
<td>C2 Document within expiry date</td>
<td>D2 Uses it</td>
</tr>
<tr>
<td>A3 Uses it</td>
<td>B3 Licença dentro do prazo de validade</td>
<td>C3 100 percent of the extinguishers are within expiry date</td>
<td>D3 Uses it correctly</td>
</tr>
<tr>
<td>A4 Uses it correctly</td>
<td>B4 Possui arquivos dos documentos</td>
<td>C4 Has an emergency plan</td>
<td>D4 Meets 80 percent of the guidelines</td>
</tr>
<tr>
<td>A5 Good</td>
<td>B5 Regular</td>
<td>C5 Has safety procedures</td>
<td>D5 Meets 71.43 percent of the guidelines</td>
</tr>
<tr>
<td>A6 Does not carry them out</td>
<td>B6 There are operational procedures</td>
<td>C6 Correct use</td>
<td>D6 Meets 40 percent of the guidelines</td>
</tr>
<tr>
<td>A7 Has a file</td>
<td>B7 Weak</td>
<td>C7 Has warning signs</td>
<td>D7 Has procedures</td>
</tr>
<tr>
<td>A8 Period of archiving not controlled</td>
<td>B8 Knows it</td>
<td>C8 Does not hold training events</td>
<td>D8 Does not do this</td>
</tr>
<tr>
<td>B9 Does not hold training events</td>
<td></td>
<td>C9 Does not have a file of the documents</td>
<td>D9 Has files of the documents referring to hazardous solid waste</td>
</tr>
<tr>
<td>B10 Does not have a supervisory system</td>
<td>C10 Does not meet NBR 14639 (uses common electricity installation)</td>
<td></td>
<td>D10 There is no control of the period of archiving documents</td>
</tr>
<tr>
<td>B11 Has a register</td>
<td></td>
<td></td>
<td>D11 Has a register</td>
</tr>
<tr>
<td>B12 Has a register of the environmental liabilities</td>
<td></td>
<td></td>
<td>D12 Does not make visits to the facilities of the company contracted</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>D13 Expiry date of the licences and documents controlled</td>
</tr>
</tbody>
</table>

**Source:** The authors (2011)
and these will serve as a guide when it renews its ISO 14001 certification, among which are:

- Creating a record of the control of the periods of archiving various documents of a gas station and their expiry dates.
- Improve the warning signs of fire hazards and unsafe acts in the area where vehicles are filled up, and especially in the storage area for hazardous solid waste.
- Miscellaneous.

The second case study can be used to help put the Gas Station Case Study 2 to become familiar with the potential adverse environmental impacts of its activities, and the main preventive and remedial actions it should take in order to contribute to establishing the environmental policy of the gas station, planning, the creation of environmental targets, setting priorities, and so forth, thus helping it to obtain ISO 14001 certification. Above all, such actions should help it to reduce or eliminate adverse environmental impacts caused by its activities. There follows a few of these recommendations:

- Development of further guidelines as to implementing PPRA and OHMP.
- Conduct training events on the various issues raised.
- Analyze more throughly the requirements and fulfilment of CONOMA Resolution 273.
- Improve the actions regarding the final disposal of hazardous solid waste.
- Miscellaneous.

This served, for the first case (the gas station with EMS certification with standard ISO 14001), as a guideline to assess the current situation of the gas station in relation to the legal requirements and identified opportunities for improvements for re-certificating standard ISO 14001. In the second case (the gas station not certificated with standard ISO 14001), it helped mainly in getting to know current legislation for the sector and contributed to the identification of trouble spots giving the senior management of the gas station, knowledge about the adverse environmental impacts caused by their activities, thus helping to make it viable to start implementing the requirements of ISO 14001.

6. Conclusion

Through the review of the literature based on current legislation in the sector, publication of research conducted and relevant operational manuals, it was possible to identify the sources that cause adverse environmental impacts and to describe the main preventive actions, as well as those for eliminating environmental impacts caused by the activities gas stations, so that this provided a theoretical basis for developing the model, which, by using indicators for the assessment categories: human contamination, contamination of the soil and groundwater, fire and hazardous solid waste, evaluated the real environmental situation of two gas stations which were taken as case studies.

Besides the fact that, with an EMS, the company complies with the standards in force in its country and its being enabled to obtain certification. Moreover, this can serve as a marketing proposal and an order winner factor which gives competitive
advantage and financial performance, as pointed out by Miles and Corvin (2000). Furthermore, Chung et al. (2005) and Ann et al. (2006) found that the certification impacts positively on both the environmental and economic performance of enterprises and Fortunski (2008) and Sabhatu and Enquist (2007) argues that the ISO 14001 standard may support sustainable development and value creation.

Moreover, Chavan (2005) found that an EMS can be a powerful tool for organizations to both improve their environmental performance, and enhance their business efficiency, reducing costs, further, the ISO 14001 was considered as a very useful tool for the promotion of technological modernization, as pointed out by Radonjic and Tominc (2006).

No study was found in the literature which covered, in an integrated manner, the categories presented in this paper, which once again highlights its importance, both in the model presented in this study and in its application. However, it is recommended that future studies explore integration further or conduct a more detailed assessment taking into account noise pollution and air quality in the vicinity caused by automotive vehicles gases and vapors from fuel, because the high concentration of such products in the air may cause adverse environmental impacts and health problems to people, as presented by Lin et al. (2005) who conducted a study of air quality affected by gasoline additives in gas service stations in Taiwan, using that country’s existing regulations as a comparison.

It is essential to highlight that the proposed model to evaluate the environmental impacts of gas stations is not limited to the reality of Brazil and Pernambuco, as it can be adapted to the current standards for any site, in other gas stations in other countries.

The main contribution of this work was to develop a viable model that can be used by enterprise, researchers and governmental environmental agencies for evaluating the environmental impacts of gas stations in an integrated manner, i.e. assessment of human contamination, contamination of the soil and groundwater, the risks of fires and of contamination to people, the soil and groundwater by hazardous solid waste generated by the activities of gas stations. This model can help gas stations both in prevention, particularly with the knowledge of the current legislation, such as in remedying environmental impacts caused by their activities, and also in guiding the actions to be taken to meet the standards of ISO 14001 certification in the search for certification.

It is believed that by using the model proposed in this research study, it is possible to diagnose the real environmental situation of the gas stations, thereby contributing to the preservation of the environment, sustainable development and above all to improving people’s quality of life.

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Further reading


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