JISTEM - Journal of Information Systems and Technology Management
Revista de Gestão da Tecnologia e Sistemas de Informação
Vol. 10, No. 1, Jan/Apr., 2013 pp.161-176
ISSN online: 1807-1775
DOI: 10.4301/S1807-17752013000100009

CONCEPTION AND DEVELOPMENT OF A SYSTEM USED TO ORGANIZE AND FACILITATE ACCESS TO ENVIRONMENTAL INFORMATION

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ABSTRACT

In São Paulo State´s) coastal area, Brazil, for several years, a chemical company discharged, without any sort of environmental control, a blend of industrial waste composed of Persistent Organic Pollutants (POPs). Lawsuits forced the company to identify and limit such deposits in order to perform the environmental recovery. A recovery project was developed demanding preparation and handling of a large amount of documents, satellite images, aerial photographs, maps and videos with the increase of the information and knowledge management issues. This condition became even more critical as the projects started to become cross-disciplinary, involving a growing number of experts, many of them established in different cities. These circumstances led to develop an Environmental Information System (BASGEO) enabling the organization and facilitation of access to such documents while increasing information safety. This work shows the development of this system and the difficulties related to the management and handling of environmental documents. The research method used was the direct observation of the system development and the semi-structured interview conducted with executives and administrative employees of the company. The results show several gains provided by the BASGEO, improving and accelerating access to information, significantly reducing the need for displacements to transport documents, thus reflecting increased safety.

Keywords: environmental information system, document management, environmental information

1 INTRODUCTION

Environmental projects are increasingly involving cross-disciplinary teams with experts generating several sorts of documents that need to be properly managed and shared. With the increase in the number and diversity of such documents, information and knowledge management issues escalate. This fact may impair projects and operations management, detrimental to the final results. This work describes the BASGEO, an Environmental Information System (EIS) used for storage and

Manuscript first received/*Recebido em* 19/08/2011 Manuscript accepted/*Aprovado em*: 16/02/2013

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management of information and its application for the identification and recovery of areas contaminated by organochlorides in part of São Paulo State´s coastal area, Brazil, covering the region between the cities of Bertioga and Itanhaém (a linear distance of approximately 100 km).

This work initially presents some considerations about the use of environmental information systems. In the sequence, some cases resulting from the improper production, use and disposal of organochloride substances are presented. Initial assumptions will allow for better understanding of the issues generated by the disposal of organochlorides in São Paulo´s coastal area, generating hindrances to the information management, which have been overcome by the use of the BASGEO.

1.1 Environmental Information Systems

The cross-disciplinary character of environmental matters and information is evidenced by the works of (Anguita, Alonso, & Martín, 2008; Lusignan & Abilock, 2008; Cole, 2007; Uiterkamp & Vlek, 2007; Voigt, Brüggemann, & Pudenz, 2006). Use of EIS allows for the better management of multiple environmental information, supporting public and private organization managers (Tachizawa & Pozo, 2010; Whitford, 2009; Cserny, Kovacs, Domokos, & Redey, 2009; Vijay, et al., 2009; Yang, et al., 2009; Wang, Zhou, Yang, & Zhao, 2008; Wang & Zhu, 2008). Within that scope, the use of EIS could be considered, both for public policy makers and the general population, in order to avoid or mitigate environmental issues (Cserny, Kovacs, Domokos, & Redey, 2009), including the public disclosure of information related to the environment (Himschoot, Férnandez, Arciet, Goldsmith, & Fabricant, 2004). These authors talk about an EIS prepared for the FREPLATA project, for environmental protection of Rio da Prata (between Argentina and Uruguay) and its beachfront, which refers to contamination control and recovery of habitats. In order to evidence activities performed by the FREPLATA project, a portal has been prepared on the Web with information aimed at different audiences, including survey of databases, documents and cartographic bases. Other studies may also be used as examples to show the use of EIS, as an EIS which helps policy makers (Brancelj, et al., 2012; Kreuz & Sauer, 2012), to the improvement of agricultural and environmental official statistics (Ambrosio, et al., 2009), to the environmental monitoring of rivers and lakes (Krouse, Jennings, & Gasparini, 2009; Patra & Pradhan, 2005; Hughes, et al., 2004), for managing a contaminated area (Carr, Zhang, Moles, & Harder, 2008) or classification of soils (Wang, Zhou, Yang, & Zhao, 2008).

Proper information management is a necessity also found in contaminated urban areas, mainly for the diversity of the situations presented. The first of them is the variety of contamination sources, such as industrial waste disposal (Machemer, Hosick, & Ingamells, 2007), improper disposal of electronic waste (Ha, et al., 2009), poorly managed recycling projects (Gutberlet & Baeder, 2008), household waste processing (Bahaa-Eldin, Yusoff, Rahim, Zuhairi, & Ghani, 2008), improper incineration (Muenhor, et al., 2009) or improper disposal of medical waste or waste from analysis and research laboratories (Vieira, 2009; Huang & Lin, 2008; Blenkharn, 2006; Silva, Hoppe, Ravanello, & Mello, 2005).

In addition to the problems related to proper identification of pollution sources (Araujo & Gunther, 2009; Almeida, Centeno, Bisinoti, & Jardim, 2007), there is a difficulty related to the correct delineation of contaminated areas and legal issues arising from them (Alhumoud & Al-Kandari, 2008; Jennings, 2008). These legal matters

include the assessment of losses suffered by the owners of areas surrounding the contamination sources (Phillips, Hung, & Bosela, 2007). Recovery of the contaminated areas also presents distinct approaches, as evidenced by the works on industrial waste management practices focused on resources sustainability (Englande & Jin, 2006), removal of materials in contaminated areas (El-Batouti, 2005), analysis of sustainable alternatives to waste incineration or discharge into landfills (Pitt, 2005), selection of areas for sanitary landfills (El-Hoz, 2008), just to mention some examples.

The diversity of occurrences, involving a large amount of information, stresses the need to use EIS, including the assessment of environmental information availability by the Enterprise Resource Planning (Lambert, Jansen, & Splinter, 2000). These authors find that ERPs are not proper for handling environmental information, requiring the use of more specific solutions (Rosa, et al., 2002; Vasil'ev, Akoev, Sal'nikov, & Smirnov, 2002), which may allow more effective benefits. According Rosa *et al.* (2002) *SDBm Plus* was prepared to support sustainable agricultural processes. ECOINFORM, analyzed by Vasil'ev, Akoev, Sal'nikov, & Smirnov (2002), aims to solve some issues faced by Russian environmental researchers due to the remote location of some research centers which limits the access to updated bibliography and information. ECOINFORM has reduced this problem by providing a large bibliographic repository supported by online systems. In its turn, TERI (Deb & Kar, 2005) also works as an electronic repository, providing several publications on CD-ROM on the Internet, enabling information and knowledge diffusion.

1.2 Persistent Organic Pollutants and the Environmental Matter

Persistent Organic Pollutants (POPs) are organic compounds industrially synthesized and resistant to environmental degradation which may accumulate in fat tissues (Marti, et al., 2010; Esposito, et al., 2009). Being also semi-volatile, they may be transported over long distances by the atmosphere before being deposited. Their effects on health are associated with serious problems, including the development of cancer. POPs include insecticides, pesticides and fungicides, many of which have been banned in several countries. However, this banning does not close the issue, as their persistence in nature extends their harmful effects, contaminating soils and waters, causing serious harm to human health and wild life.

The literature has several cases of accidents and incidents involving production, handling or improper disposal of POPs. In Turkey, in the decade of 1950, wheat grains treated with hexachlorobenzene (HCB) fungicide, to be used as seeds, were used as food, contaminating thousands of people (Cripps, Peters, Gocmen, & Dogramici, 2006). In 1976, an explosion of a tri-chlorophenol reactor released dioxins reaching a broad area and affecting thousands of people in Seveso, Italy (Consonni, et al., 2012; Engelhaupt, 2008).

In the United States, in the Love Canal (Niagara Falls) an excavation originally aimed at electrical energy generation was abandoned and started to be used as industrial waste deposit. Upon urbanization of the area, between the decades of 1950 and 1970, organochloride substances generated by that improper disposal were found in the playground of a school and on the gates and yards of the houses. Reports described cases of damage to people´s health as well as the birth of children with deformities (Phillips, Hung, & Bosela, 2007).

In Duque de Caxias, Brazil, an area was contaminated by disposal, on the soil, of approximately 350 tons of hexachlorocyclohexane (HCH), among other

organochlorides. As a result, HCH, DDT, trichlorobenzenes, trichlorophenols and dioxins concentrations exceeded the limits deemed to be acceptable on the soil, with high risks for the local population (Asmus, et al., 2008).

2 CASE STUDY

In order to best describe the BASGEO conception and development, this case study was divided into three parts. At first, an insight into the methodology was done, explaining how this study was conducted. In the second part, the environmental context that led to this system conception is presented, analyzing POPs improper disposal background in São Paulo State´s coastal area. This analysis allows for the understanding of the needs that required the preparation of this Environmental Information System (EIS) and the guidelines adopted in the BASGEO project.

2.1 Methodology

The paper uses a case study methodology to analyze the development of an Environmental Information System (EIS) by Rhodia. The research method used was the direct observation of the system development and the semi-structured interview conducted with executives and administrative employees of the company. The observation and the interview were complemented by information obtained from primary sources (internal documents and reports). The analysis of this information was conducted with the support of the conceptual framework that has emerged from the literature review. This methodological framework was supported by a specialised bibliography (Woodside, 2010; Yin, 2008; Gerring, 2006; Hancock & Algozzine, 2006; George & Bennett, 2005).

2.2 Disposal of Persistent Organic Pollutants in São Paulo´s Coastal Area

During part of the 1960 and 1970 decades, the areas located in the cities of Santos, São Vicente, Cubatão, Praia Grande and Itanhaém,São Paulo State´s Coast, received organochloride substances, without any sort of control or monitoring, contaminating soil and ground water, impairing the health of the workers and of the population from the surrounding areas (Almeida, Centeno, Bisinoti, & Jardim, 2007).

This improper disposal of organochlorides was done by Clorogil in several areas from São Paulo´s coast and it started around the 60's, continuing until mid 70's. Clorogil was established in 1965 by Progil - Socyeté Anonyme and by Carbocloro S.A., but its control was transferred to Rhodia Indústrias Químicas e Têxteis in 1976 (Magalhães, 2006; Couto, 2003), which inherited a large environmental liability from the areas contaminated by industrial waste.

During decade of 1980, Rhodia and the Environmental Company of São Paulo State (Cetesb) were reported to the São Paulo State´s Public Prosecutor´s Office due to improper disposal of organochloride industrial waste. In addition, labor suits were initiated against Rhodia due to the contamination of Clorogil´s workers. During that same period, the issue was reverberating in the press and the company suffered with the increased pressure of the organized civil society.

All the events required the start-up of a process to identify and limit the areas contaminated by persistent organic pollutants (POPs) on São Paulo State´s coast for further environmental recovery. Three major projects were conceived by Rhodia,

aiming to identify, quantify and limit the contaminated areas. At first, Pilões and Perequê regions, located in the city of Cubatão were investigated. Later, a comprehensive study named "Projeto Baixada Santista" (Santos Lowlands Project) was developed, aimed to identify and limit other areas contaminated by POPs, investigating approximately 2.600 square kilometers along São Paulo State´s mid-south coast.

In Pilões region there is a clandestine old residential and industrial waste dumping site, informally known as "Lixão dos Pilões" (Pilões Dumping Site). That dumping site is located near the initial section of the upward lane of Imigrantes Highway (connecting São Paulo State´s coast to the capital city). In that site, waste disposal started during the 60's and continued until 1979 (Magalhães, 2006; Couto, 2003). Simultaneously, the area was incipiently occupied, and such an occupation was intensified after the building of the Imigrantes Highway during the decade of 1970. After conclusion of the upward lane civil works, lodgings used by the workers were abandoned and started to be used as a residence by new families.

Even after deactivation of this clandestine dumping site, the area continued to be occupied, giving rise to research concerning the effects of contamination by organochlorides in that population (Santos Filho, et al., 2003). The study covered 238 people living in the area occupied by such dumping site and surroundings, analyzing the concentration of organochlorides (hexachlorobenzene, hexachlorocyclohexane, DDT, Aldrin, Dieldrin, Endrin, and others). The control population was composed of 258 people living in the City of Cubatão.

A study performed by Santos Filho *et al.* (2003) shows that, among the residents of Lixão dos Pilões, the average HCB concentration in the blood was 4.66 µg/L, 155 times higher than the average of the control population (0.03 µg/L). For DDT, the average content among the residents from Pilões was 3.71 µg/L, twice higher than the average found in the control population (1.85 µg/L). A similar condition was found for hexachlorocyclohexane, with the Pilões population presenting an average concentration six times higher than the control population (0.84 µg/L against 0.13 µg/L). In a previous research, Santos Filho *et al.* (1993) studied organochloride blood concentrations in 242 children living in six districts located by the margin of Cubatão City's main rivers. From that total, 73 children (30%) presented results compatible with high exposure to organochlorides.

Due to the presence of POPs in the Lixão dos Pilões, lawsuits initiated by improper disposal of industrial waste had Rhodia as one of the major sued companies. But, due to the presence of waste from other industries, the company looked for support from the São Paulo State Industries Confederation (Ciesp), aiming to gather efforts in order to recover such a dumping site.

Parque do Perequê was another area that received organochloride industrial waste in the City of Cubatão (Magalhães, 2006), located at the right margin of a river bearing the same name, which flows down to the Serra do Mar (Mountain Range of the Sea) heading for the coast. In November, 1989, during earthbank works to enlarge that park, organochloride products were found. The area was closed and the São Paulo State´s Prosecutor´s Officeinstituted an Injunction against Rhodia, liable for improper disposal. In April, 1990, the company removed the contaminated waste and soil of this dumping site which was surrounded by fencing and started to be monitored.

With the purpose of checking whether there were still organochloride compounds in the area of Parque do Perequê, an environmental expert inspection was

performed. The inspection showed that the remaining contaminated spots were concentrated at the river's right margin, between the Serra do Mar hogback and Eletropaulo's (electricity distribution company) transformation and transmission station. It was found that this area should have been deeply investigated by soil, surface water and underground water samples and analysis.

In September, 1993, Rhodia prepared the "Plan for the Qualification, Quantification, Dimensioning and Origin Definition of Chemical Products" discharged in the areas suspected of being contaminated. In 1994, an environmental impact assessment and recovery was presented to the Cetesb covering 11 areas in Baixada Santista contaminated by organochlorides. During the second half of 1996, Rhodia presented to the 3rd Circuit Court of Cubatão City a proposal for a complementary hydro geological and geochemical investigation and one environmental recovery plan for Parque do Perequê.

In the two previous cases (Lixão dos Pilões and Parque do Perequê), areas limitation was facilitated by indications that pointing to the existence of organochlorides, making actions for recovery of the contaminated sites more objective. However, there were reports that organochlorides disposals had been done in other areas along São Paulo State´s south coast further to those already identified. That led to conception of a methodology enabling identification of potentially contaminated regions, choosing areas that would be investigated by field teams.

An analysis of a historical sequence of aerial photographs was performed, detecting areas that could have served as clandestine dumping sites of chemical waste. According to the scope of this methodology, potentially favorable sites to such a disposal should have the following conditions: *i)* easy access to trucks and heavy vehicles; *ii)* distant from urban centers, avoiding rising of concern about such activities; *iii)* not presenting large vegetation, thus facilitating truck traffic and waste disposal. Upon finding areas with those characteristics in a certain set of aerial photographs, the evolution in later years was checked, looking for signs of earth works or material disposal. In affirmative cases, a field team was sent to the area in order to collect soil samples by manual auger, following a geochemical sampling mesh, for further chemical analysis searching for the presence of organochlorides.

To provide an example of this methodology, it is important to notice that, in some instances, discharge of toxic material was done in a previously decommissioned sand harbor, in areas previously used for extraction of sand for the civil construction. In these cases, based on the aerial photographs taken in different years, it was possible to see the area evolution. After a period of sand extraction, forming a trench, the activity interruption can be observed. Some years later, the same trench could be filled with some type of material, leading to suspect that industrial waste was being improperly disposed of. Upon such suspiciousness, a field team was sent to the dumping site, soil samples were taken and analyzed in the laboratory. The work started to be developed in 1993, by Rhodia, along São Paulo State´s south coast and named as "Projeto Baixada Santista". In total, 2,600 square kilometers ² were analyzed, starting in the city of Bertioga, at the central part of São Paulo´s State coast, up to Peruíbe, southward.

2.3 THE BASGEO

Together, the three projects covered geographically large areas, with cross-disciplinary teams, performing several field works, chemical analyses, expert analysis and reports, requiring the preparation of a large number of documents, photographs,

maps and chemical analysis results. The areas also had legal documents, satellite images, news given by the press, drawings and several videos associated with them.

During the Projeto Baixada Santista, problems related to access to documents and information flow were identified, resulting from the large number of experts involved and located in different cities from São Paulo State (Cubatão, Santos, São Vicente, São Paulo and Paulínia). As distances between the cities could exceed 150 km, that generated frequent displacements only to deliver documents. For example, when a report or document requested by the regional management in Cubatão was in São Paulo, it was necessary to send an employee specifically to analyze that material, spending time and generating extra costs. During that process, documents could also be lost, delaying project progress or compromising the required secrecy.

Safety matters hindered documents from being sent by electronic media or made available by online systems. A lot of information was confidential, as it involved results of analyzes of areas suspected of being contaminated, including expert reports and documents required to the defense of the company in miscellaneous lawsuits. Furthermore, team fields did not have remote access to the Internet, which would make it hard to use any online system. It is interesting to notice that, although geographic distances were shorter than the ones faced by Russian environmental researchers (Vasil'ev, Akoev, Sal'nikov, & Smirnov, 2002), some conditions were similar, generating difficulties to interchange information.

Looking for a solution to this issue, it was proposed to create the BASGEO, an Environmental Information System, with capacity to digitally and safely store a large amount of environmental documents, facilitating the recovery of information regarding the recorded areas. This solution would find similarity, from the conceptual perspective, with the TERI (Deb & Kar, 2005) and other information and documents repositories.

During the BASGEO conception, it was decided to use prototyping, which consisted of fast production and fewer costs, of an experimental system submitted for end user assessment (Warfel, 2009). As the prototype is a functional version of an information system, or part of it, users may use it to better understand its functioning and necessary requirements. That will allow refining of the prototype, upon testing of more enhanced versions which the users assess. Although the project conception was well performed, some members of the team that would use the BASGEO still had some questions about the system's practical operation, which could be easily solved upon prototype preparation. That would speed up the presentation of the system's main resources, allowing discussing the implementation of some solutions and ease of use.

Some assumptions were considered upon the BASGEO conception: *i)* easy to install, without the need of extra software and licenses; *ii)* use of safety systems that would hinder unauthorized people from using their information; *iii)* simple to use, allowing fast access to information; *iv)* database and information portability, assuring independence towards the software used for management.

At first, the possibility of the system to use a fully proprietary graphic interface was considered, and even a prototype for testing was prepared. That solution was believed to facilitate the system use by directing the users to specific functions. However, initial assessments showed that proprietary interface use would not facilitate it as users would need longer learning time. That fact led to an interface presenting elements which were more familiar to Windows users, which were deemed to be more adequate and refined upon the creation of new prototypes. For that, the Object Pascal

language was chosen, at the Delphi commercial version, supplied by Borland, for its performance, easy programming, resources and documentation availability.

In parallel to the prototypes tests, several documents started to be recorded. During the project conception, it was defined that the research should be performed in the entire content of each document and not only by key words or metadata. That would extend research possibilities of documents with specific contents or details, which were considered as essential by the technical team using the BASGEO. In addition, it was deemed mandatory that people had to have access to one digital copy of the documents, as that would allow checking of the signatures, protocol stamps (especially important for legal documents) and hand-written notes, drafts, and other details. To meet those two requirements, an option was made to have documents scanned in the GIF format (Graphics Interchange Format), as it includes an embedded data compression algorithm LZW (Lempel-Ziv-Welch), reducing files to a final size. In addition, the GIF format is compatible with several platforms and source codes for images recording and reading is found in different languages. Another advantage provided by the GIF format is that it is a standard accepted by Web browsers. In the future, should there be the option of sending the system to the Web, documents will already be in a proper standard.

After scanning, content of every text was converted through OCR (Optical Character Recognition) into file texts compatible with ASCII standard (American Standard Code for Information Interchange). Choice of ASCII format was made due to the fact that it was a largely used ANSI standard (American National Standards Institute), assuring files portability. In order to assure such compatibility, accents used in the Portuguese language were suppressed, avoiding use of the ASCII table extended part, which would impair future use of other systems or platforms. Concerning security, once database and information were consolidated, the entire content (images and texts) was encrypted using symmetric a key algorithm. Efforts were made aiming to avoid access to the file content by unauthorized people. The same algorithm was implemented into the search and reading program code, used by the users to access the documents. Specific databases were assembled with documents from the Lixão dos Pilões and Parque do Perequê areas, recorded on CD-R and distributed to the users. Project conception included the distribution of new copies on CD-R format upon each update of a database. Figure 1 summarizes these procedures.

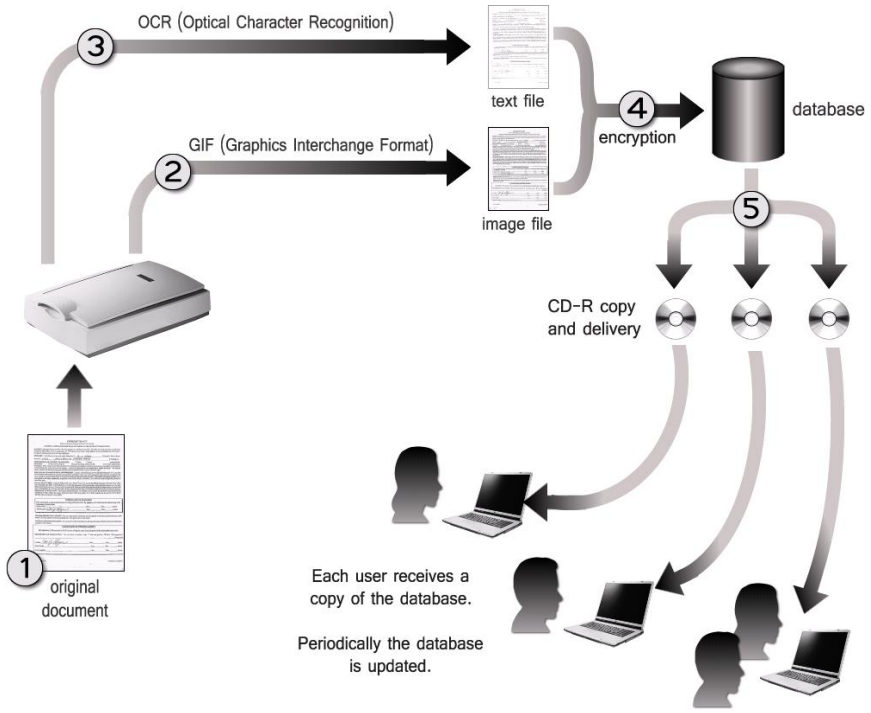

Figure 1 - Synthesis of recording process of documents at the BASGEO

Access to the search program is only made by previously registered users with access controlled by password. Basic search can be done by the following criteria: *i)* word or phrase; *ii)* document date; *iii)* document type. In case of a search by word or phrase, which is the most frequent, the user indicates the desired terms and the system sweeps all the registered text files. As previously mentioned, each text file was generated by OCR from a digitalized copy (in GIF format) of the original document. Therefore, upon finding the word or phrase in a text file, the system automatically identifies the corresponding scanned file. A list with the files having the word or phrase is presented to the user. He/she can only check the file with a text transcription (highlighting the section with the specified word or phrase) or analyze one copy of the original document (which can also be printed). There is also the possibility of refining the process and searching new words or phrases only among the documents found in the previous search. Figure 2 summarizes this process which is quickly performed by checking 800 documents at about two seconds.

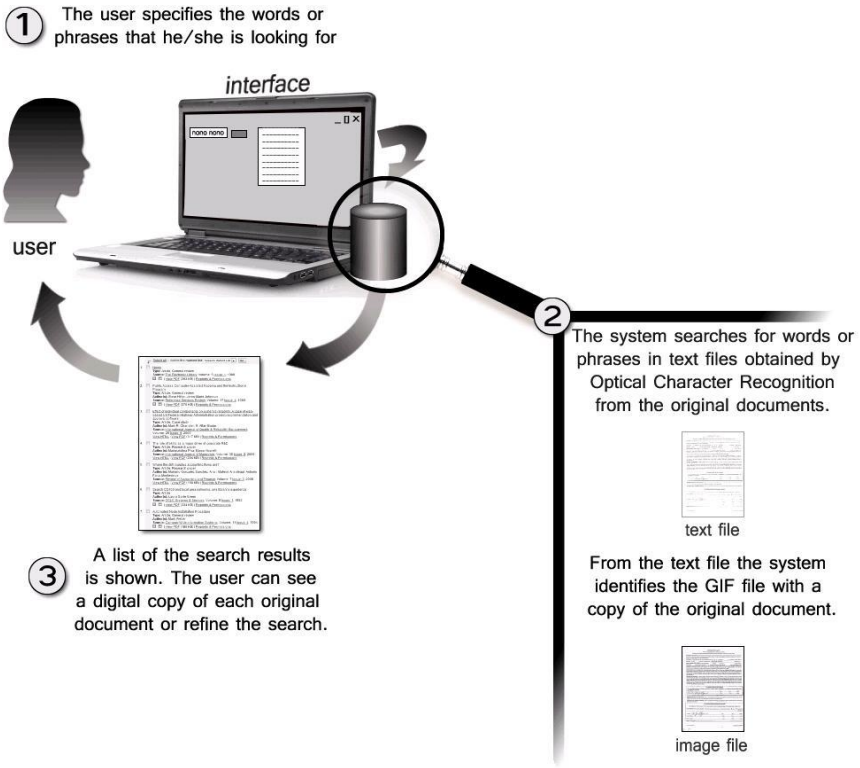

Figure 2 - Searching for documents at the BASGEO

Another search possibility, as previously mentioned, allows checking only documents of one specific type (technical reports, bulletins with chemical analyses, legal documents, news published in newspapers or magazines, among other categories). There is also the possibility of analyzing documents with original copies generated on a specific date.

A solution of this kind presents characteristics of Tactical Level Systems, as such systems are aimed at the development and implementation of strategic decisions mande by the organization's top hierarchical levels (Côrtes, 2008). It also presents features related to the Strategic Level Systems, which serve more comprehensive and long term decisions, with stronger impact on the company. It can also be found that the BASGEO is a Knowledge Work System (Laudon & Laudon, 2011) or Knowledge Management System (O'Brien & Marakas, 2010), as it contributes to the increase in the information flow across work team members and acts as a catalyst in knowledge creation and diffusion, accelerating conception of the actions. Members from the several teams are granted easy access to express knowledge, which is the one coded and accepted transmission by formal language (Nonaka, A dynamic theory of organizational knowledge creation, 1994). Such knowledge will be further used in new documents preparation, which are incorporated into the database and information, enhancing what (Nonaka & Takeuchi, 1995) call the spiral of knowledge.

2.4 Incorporation of Multimedia Files

After some time of use, a need was evidenced to incorporate multimedia resources such as videos and sounds and images (pictures) added to the document base copies of articles broadcasted by television news and technical videos produced by the industry itself. Analysis of that material assumed a strategic character, as the news broadcasted in television news could impact on Rhodia's image.

To enable the search being performed by phrases of specific words, the same criterion was used for the printed documents such as the transcription of the dialogs from the videos for text files. For each static image (pictures, for instance) one descriptive text was recorded, informing what that was about, place and time when it had been prepared. In practical terms, few changes were required to incorporate such resources into the graphic interface. Search continued to be performed with the same functions (by word or phrase, document date or document type), with the presented list indicating the type of file available (digital document, video, sound or static image). The interface received inclusion of resources for the presentation of new multimedia resources.

3 CONCLUSIONS

Improper industrial waste disposal may cause severe environmental issues which are oftenhard to solve. Projects for the identification, characterization and limitation of the contaminated areas are rare and the efforts to recover them require experts from several areas. This diversity of professionals, added by the efforts dedicated to solve issues, generates a large amount of documents such as bulletins of chemical analysis, studies, reports, expert opinions, photographs, videos, and maps among others. While the involved professionals generate a large diversity of documents, they need to have access to the information generated by their peers. That ends up creating an information access management issue, a condition that might assume more critical outlines if they are associated legal matters.

Improper disposal of organochloride industrial waste in São Paulo State´s coast brought this type of situation, with the participation of professionals from several areas, demanding access to an increasing amount of documents and information. Associated legal matters and the large extension of the investigated areas increase the issue. The BASGEO is an example of how an Environmental Information System (EIS) can be used to support projects of identification and recovery of degraded areas and management of environmental liabilities. Besides organizing and facilitating access to environmental documents and information, it facilitated the integration of cross-disciplinary teams even when distributed across geographically distant sites.

According to the users, several gains were provided by the BASGEO, improving and accelerating access to information, significantly reducing the need for displacements to transport documents, thus reflecting increased safety and meeting of their personal needs (Bondarenko, Janssen, & Driessen, 2010). This granted more promptness to the environmental management of the contaminated areas, reducing response time to certain legal demands by facilitating the recovery of information concerning specific analyses or performed expert assessments (Grahlmann, Helms, Hilhorst, Brinkkemper, & van Amerongen, 2012). Another positive impact of the use of such a system was reduced rework (mainly of sampling and laboratory analysis), facilitating day to day operations.

Teams related to environmental projects have been increasing, adding more researchers, technicians, consultants and experts. To meet that goal, it is necessary to facilitate information flow, demanding specific information systems solutions, similarly to what was used in the reported projects. In that sense, the BASGEO has facilitated the integration of new people to the work teams, as organized access to documents and information has helped the sharing of express knowledge, which is the one coded and accepted transmission by formal language (Nonaka, 1994). That system, when

organizing and sharing already existing knowledge, increases the knowledge spiral (Jakubik, 2011; Nonaka & Takeuchi, 1995), contributing to the best environmental management of the organizations. The BASGEO is a system that goes beyond simply providing a solution (Rodrigues, Maccari, & Simões, 2009), innovating the way the management of environmental information is processed. It is important to consider that the solution adopted was technically simple, but with a major impact on the management of documents. The BASGEO allows the decentralization and distribution of workflow functions (Pešović, Vidaković, Ivanović, Budimac, & Vidaković, 2011) despite the need for a better classification of documents (Rocha, et al., 2013; Yang, Lin, & Wei, 2010; Karanikolas & Skourlas, 2010).

4 LIMITATIONS

This research has some limitations, which are the search of new opportunities. It would be interesting to compare the BASGEO with other management systems of information and documents, checking the improvements that could be implemented. Also, online solutions could be assessed, which facilitate the management of the same document base.

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