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RESPONSIBLE CONSUMPTION AND PRODUCTION (RCP)

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Keywords

SDGs; Ethical consumption; Ethical production; Cleaner Production; Energy Efficiency; PYMEs; Argentine Republic.

Abstract

The University of Centro Educativo Latinoamericano (UCEL), related to the Argentina Methodist Evangelical Church (IEMA), works responsibly and with commitment to achieve the United Nations' Sustainable Development Goals (SDGs) and has the SDG 12 in particular focus[*].

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Introduction

It is well known that Sustainable Development is the type of development that satisfies people's current needs without compromising the capacity of future generations to satisfy theirs. In this context, the United Nations Organization established a series of so-called Sustainable Development Goals (SDGs), which are a call to action by all countries to eradicate poverty and protect the planet as well as to guarantee peace and prosperity.

Within this list is objective No. 12, which is Responsible Consumption and Production (PCR). It literally says: "Guarantee sustainable patterns of consumption and production". Responsible production is the one in which the transformation of raw material into finished product is optimized, the waste generation is reduced, and the least amount of energy possible is used. This assertion prompts us to consider two basic concepts simultaneously: Cleaner Production (CP) and Energy Efficiency (EE).

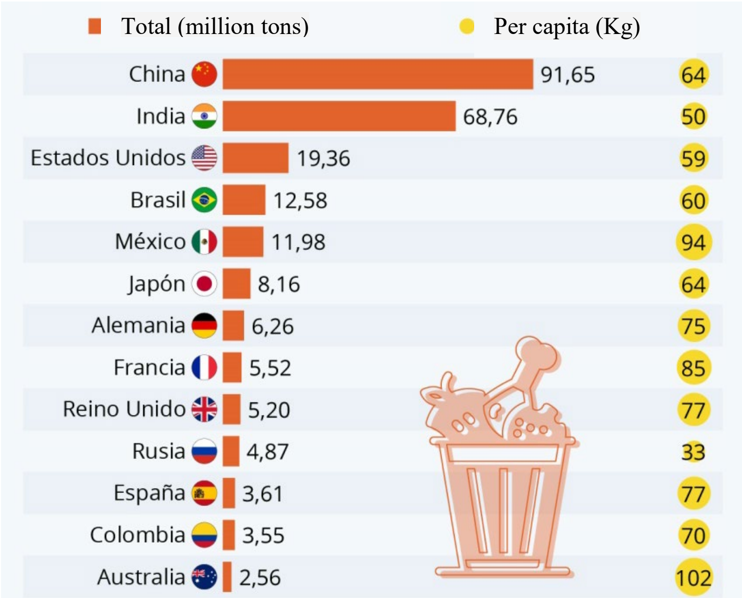
Responsible production is directly associated with cleaner production (CP). Within the territory of the Argentine Republic there is an unquestionable and widespread belief among small and medium-sized enterprises (Pymes, in spanish) that environmental protection measures are expensive and that their application makes companies lose competitiveness. This leads to a lack of interest and investment of resources in pursuit of sustainable development in the industrial sector of the country. However, there are plenty of studies that proper management of raw materials and energy translates directly into a decrease in production costs, and indirectly into an improvement in the quality of life of the employees of these companies and, as last and no less important consequence, a decrease in the environmental impact (4, 25, 27). Therefore, the resolution of many conflicts between the industry and the environment must be approached with a cost-effective management, preventing the contamination generated by the non-transformation of raw materials into products and the waste of energy in inefficient processes.

The reduction in pollution that we can achieve in production processes is what is called cleaner production (CP), being a work methodology that allows us to reduce the consumption of raw materials and energy, reduces effluent treatment costs and Above all, take care of the environment where it develops. Its application is carried out in companies that produce food, metal-mechanics, textiles, fruit and vegetables, restaurants, etc. The main items that are worked on are: rational use of water and energy, proper waste management, good production practices, maintenance, etc.

In this context, the Environmental Management and Incorporation of Cleaner Technologies for SMEs Project was created in Argentina, with financing from the Inter-American Development Bank (IDB) and through the Libertad Foundation, located in Rosario, Santa Fe province. The guides of cleaner production in SMEs offer guidance on reducing environmental impacts in this type of company.

Responsible production is actually a necessary but not sufficient condition in order to achieve the essence of SDG 12. According to the 2021 Food Waste Index, published by the United Nations Environment Program (UNEP), 931 million tons of food are wasted in the world each year (17% of the total food available to consumers).), of which 569 million come from households. The remaining amount is attributed to restaurants and other food services (244 million tons) and retail trade (118 million tons). Globally, per capita, 121 kilograms of food are wasted at the consumer level each year, and 74 kilograms of those are wasted in households. This enormous waste is produced by different circumstances: distribution and logistics problems, lack of capacity to maintain the cold chain, inaccessibility of some populations depending on the climatic condition, lack of knowledge of the population to keep food in good condition until its consumption, etc.

Graph 1. Estimate of the annual volume of food wasted in households of countries selected for this study.



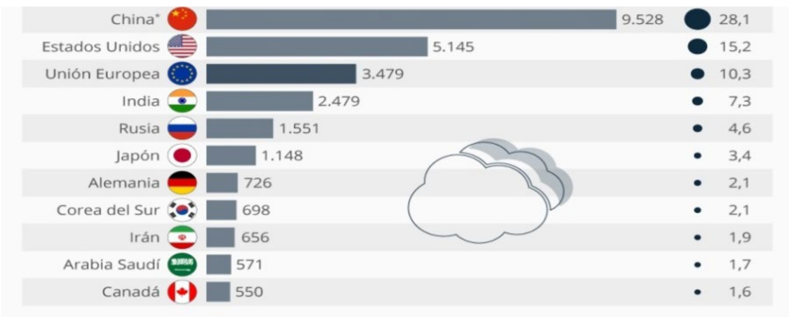
Source: food waste index 2021 – UNEP.

Unfortunately, since long time ago, we live in a society that seeks to fulfill all of its life expectations in the consumption of tangible and intangible goods. But that excessive consumption causes, among other issues:

- The generation of different kinds of waste in growing quantities, whose final destination in almost all cases leads to increase environmental problems derived from its inappropriate accumulation.
- The loss of big food quantities without its proper utilization.
- The elimination of forests, vegetation, rainforests, etc., in order to create suitable lands for crops that satisfy society's food requirements, which could be avoided if food was better distributed and if all products were used entirely.

- The precious metals mining with no practical value, just for financial speculation, that causes highly harmful changes to the landscape and the surroundings where multiple societies with subsistence economies develop their activities.
- The loss of CO_2 retention due to the elimination of trees so as to satisfy the excessive comfort demands of our society.
- The pollution of surface and groundwater because of the aforementioned activities.
- The loss of enormous amounts of water, required for subsistence agriculture and needed by whole populations.
- The pollution of soils with hazardous substances and the creation of environmental liabilities of which no one is held accountable.
- The air pollution caused by the use of non-renewable fossil fuels that produce Greenhouse Gases (GHG), particulate matter, etc., coming from sources such as terrestrial and aerial vehicles, industrial chimneys and solid urban waste dumps, among others.

Graph 2. Countries and regions with the highest volume of CO2 emissions in 2018 (millions of tons).



Source: BP Statistical Review of World Energy 2019.

Both in production and consumption of goods and services, continental and regional differences are remarkable, due to the development level of their inhabitants, their culture, their customs, their technological development, etc. Therefore, when the global situation on this matter is analyzed, there is a risk of generalizing completely dissimilar realities. That is why, in accordance with the axes of this book, and without ignoring that Latin American countries have very different realities, we will specifically restrict the analysis to a higher education institution, the University of Centro Educativo Latinoamericano (UCEL), located in Pellegrini Av. 1332, Rosario (Republic of Argentina), which is inserted into the Latin-American reality in RCP. Thus, section 1 shows how this University concretely works for the compliance of SDGs in general, what is the current situation, what are present and future plans in connection with them and to what extent, aiming to achieve them, UCEL fulfills its mission and institutional vision, for which it was created in 1992.

Thereupon, section 2, which is the core of this chapter, shows how UCEL effectively contributes to the compliance of SDG 12, always bearing in mind the axiom: think globally and act locally. Taking into account that the axis of this book is the link between higher education institutions, ethics and SDGs, it describes how and how deeply UCEL is actively involved so that this goal can be brought into practice in order to achieve a proper knowledge transfer in the regional area. In this respect, UCEL promotes responsible production through its Pilot Plant of Vegetable Oils and by means of research projects aimed at generating high protein value foods, using regional raw material and with low-cost production. This University also intends to raise awareness on responsible consumption through multiple strategies: a postgraduate degree, "Environmental Management Specialization" (EGA in Spanish), and concrete actions executed by the author of this chapter within the framework of the University's environmental activities, in relation to air, soil and water contamination problems.

Finally, some brief conclusions and reference bibliography are included.

University of Centro Educativo Latinoamericano (UCEL) and Sustainable Development Goals (SDGs)

Political and economic context

In a context of constant changes in economic growth policies and monetary instability due to the constant and growing inflation in the country, companies and universities are immersed in the challenge of developing even in the presence of a political, economic and social crisis, aggravated by the effects of the COVID-19 pandemic). In July 2022, the situation reached a breaking point that worsened with the resignation of Economy Minister Martín Guzmán, a decision criticized by the coalition itself. As a consequence, a currency run was triggered that led to the outbreak of protests in various parts of the country on July 9 (Argentina's Independence Day) and in the subsequent resignation of the Minister of Economy Silvina Batakis after 24 days of office. The position was occupied until then by the president of the Chamber of Deputies, Sergio Massa. In this framework, Argentina had three Ministers of Economy in only one month of monetary exercise. Later, political analysts, journalists and members of political parties such as Together for Change accused the government of an internal conflict generated by a sector close to Vice President Cristina Fernández de Kirchner, which triggered a series of political conflicts between the ruling party and the opposition, which continue to destabilize and obscure the possibility of establishing solid and long-term economic development policies throughout the national territory.

There is a consensus that universities should leave academia to take on the problems of the regions in which they are inserted for the purpose of, at least, proposing alternatives to solve the most pressing problems of society in general and of the most vulnerable population in particular, always from the perspective of Sustainable Development (SD). This positioning of the universities must be able to be translated into concrete facts: research, academic offer, services to the community, extension courses, etc.

The University of the Latin American Educational Center

The University of the Latin American Educational Center is a private, non-profit university based in Rosario, Argentina. Established in 1993, it was the first Methodist Church University in Argentina and the first private degree-granting university in this city. Its origin dates back to the arrival of two missionary teachers sent from the United States by the Methodist Episcopal Church to open a primary school for girls, the North American College, in 1875, under the patronage of President Domingo Faustino Sarmiento. Secondary schools and high schools were later added, and in the 1950s the College became coeducational.

UCEL belongs to the International Association of Methodist Schools, Colleges and Universities (IAMSCU). He is also connected with the General Board of Higher Education and Ministry of the United Methodist Church in Nashville, Tennessee, USA.

In this context and with the growing development and expansion over time, UCEL has been created and carries out a solid scientific and technological training of professionals to contribute to the economic, social and cultural development of the region. This could be done with an understanding of the modern world and an ethical commitment, which would in turn allow both its students and teachers and researchers to assume their civic and professional responsibilities, with a sense of ethical commitment to others and the environment.

In addition to the various diplomas for specialists in the fields in which UCEL develops, the careers that it currently presents are those that are presented below. Within the Faculty of Law, the following: University Faculty, Public Auctioneer and Real Estate Broker, Notary Public and Bachelor's Degree in Administration and Commercialization of Real Estate.

The Faculty of Chemistry presents the following degree courses: Bachelor's Degree in Nutrition, Engineering in Food Technology and Engineering in Information Systems, and University Analyst in Information Systems. This faculty includes the following Postgraduate courses: Specialization in Maternal and Child Nutrition and Specialization in Environmental Management.

For the Faculty of Cs. Economic and Business: Public Accountant, Bachelor's Degree in Business Administration, Labor Relations, Marketing, Economics, Hotel Administration and Tourism Business Administration, Within the Postgraduate, there is a Master's Degree in Labor Relations and Human Resources, and Specializations in Taxation, Accounting Expertise and Applied Economics. The Wesley Institute teaches a degree in Theology in the distance modality and a series of courses on theological issues and training for pastors of Protestant churches.

UCEL ethical and educational policies

Within its academic statute, this university plans, mainly, the following purposes:

a. Comprehensive training of teachers and students within the Christian tradition and the highest universal values, through the dissemination of culture and knowledge that guarantee their insertion in the community, and will be committed to the democratic and republican system of life.

b. Promotion of a university environment that tends to the search for truth, knowledge and excellence, through integrating approaches, based on diversity and pluralism.

c. Balance between traditions and innovations and between the development of the mind, body and spirit.

d. Integral academic, humanistic and scientific training in the different professions, through the Academic Units that compose it, through undergraduate and postgraduate courses, and extension, research and transfer activities.

e. Investigation of the widest spectrum of possibilities, prioritizing issues related to its educational offer and the needs that are manifested within the community.

f. Cultural, scientific and technological projection at the service of the interests of the region, the Nation and humanity.

In addition, the University Statute expressly excludes any profit motive. Any surplus that may exist in any exercise of the Institution, will be destined to solve obligations and to improve the academic activity, and cannot be distributed in any way among the members of UCEL, nor to give them a destination other than that of their object.

Regarding the structure of the authorities of this institution, the general management is in charge of a Superior Council, which will be made up of the following members: Chancellor, Representative member of the Board of Directors of AUCEL, General Vice Chancellor, Academic Vice Chancellor, Vice Chancellor Financial Economics, Chaplain, Deans and Teaching Representatives (one per faculty).

Together with the Superior Council, the Board of Directors of the Association of the University of the Latin American Educational Center (AUCEL) is developed, which delegates to the Rector the legal representation of UCEL and is supportive and responsible together with him and the Superior Council, before the competent authority, compliance with current legal regulations, as well as those established in the Academic Statute.

UCEL proposals for compliance with the SDGs

Thanks to the resources they have, to a greater or lesser extent, universities in general have a lot to contribute in relation to the fulfillment of the Sustainable Development Goals; Furthermore, we can say that they play a central role in this sense, since they are one of the bases that countries have to generate, manage, transfer and apply new knowledge that allows them to successfully face the fulfillment of the SDGs.

Particularly in Latin America, where Argentina is located, we must review our development model, how we manage our resources and how we supply useful products to society. This must be realized without generating polluting waste and, if it occurs, by acting to reduce or eliminate its negative impact on our environment. In an ideal world this may be even done, increasing our efficiency in the use of energy and eliminating the use of those expendable devices or objects.

For this reason, the actions that UCEL carries out to fulfill the SDGs in the scope of its sphere of action will now be detailed:

- *No Poverty*

In current and future society knowledge, the best way to fight poverty is educating to the highest level possible the population interested in acceding to higher education. Accordingly, UCEL offers an education of excellence within the framework of Christian values.

- *Zero Hunger*

Besides the degrees related to food production and the study of food nutritional qualities, offered by UCEL since its beginnings, current research projects aim to achieve high nutritional value foods at a low cost, especially for the population with fewer resources. Research has a regional sense, by using raw materials available in the environment to avoid long distances and consequent emissions of GHG.

- *Good Health and Well-being*

Broadly speaking, health has a place in UCEL: degrees, courses, certifications, applied research, etc. Well-being is present in the degrees that tend to the care of material goods and the protection of public and private rights. Sport activities for the students, first aid courses courses and the commitment of its members to collaborate with the health care of people from at-risk communities, away from urban centers, tend to achieve this SDG.

- *Quality Education*

Academic excellence is UCEL's main objective since its origins. The improvement in the teacher staff training, the updating of study plans and the creation of new degrees and courses have been the primary aim for UCEL's educational community since 1992. The goal is the improvement of the quality of the offered degrees and of the experimentation levels, the increase of the bibliographic collection and the permanent training of the staff to achieve academic excellence.

- *Gender Equality*

In UCEL, the attention to gender policies in general and gender equality in particular has been constant since its creation. Regarding the University staff, there is a remarkable predominance of the female gender in the teaching and non-teaching staff, as well as in the student body. Furthermore, gender equality is verified in research groups, extension and teaching. The selecting process of the staff in distinct areas has this concept as a priority, and it is considered natural and not an imposition.

- *Clean Water and Sanitation*

Within the University, where around two thousand people per day perform their activities in normal times, drinking water is monitored in the institution's physical-chemical and microbiological laboratory, currently in certification process. Specialized personnel are in charge of sanitation in the different educational spaces throughout the day. The use of sanitizers, cleaning equipment and the monitoring of common areas allow to ensure absolute sanitation conditions for everyone in UCEL.

- *Affordable and Clean Energy*

Excessively spent energy is a polluting factor due to its fossil fuel-based generation. Reducing consumption is a way of reducing contamination. Since most of the energy is used for lighting, incandescent lights have been replaced by low-consumption lights, with a significant reduction in energy consumption. In the Pilot Plant of Vegetable Oils, solar panels will be installed to provide energy to the laboratory and services area.

- *Decent Work and Economic Growth*

UCEL's whole staff conducts its activities within the framework of legal standards, in compliance with Hygiene and Safety Work directives. The working conditions of the staff are characterized for being decent and appropriate. Its economic growth is directly linked to its degree of dedication and commitment. The institution is non-profit and reverts its surplus into infrastructure improvement as well as services for its staff and community.

- *Industry, Innovation and Infrastructure*

UCEL owns a Pilot Plant of Vegetable Oils that is unique in South America because of its performance level, its emphasis on innovation and the quality improvement of the processes developed there. Designed to provide services for industries of the largest oil-production center in the world, it also allows training for students and teachers, and the creation of new products based on processes wastes through applied research projects with a regional focus. The Plant characteristics and processes will be described in section 2.1.

- Reduced Inequalities

Using different strategies (e.g. extension tasks), UCEL strives to fight the environment’s social inequality contributing with knowledge and culture. The aim is to level life conditions of the local and regional community. Applied knowledge allows to broaden the views of the University’s recipients and a change in their worldview with very positive results.

- Sustainable Cities and Communities

UCEL promotes a more sustainable city with significant contributions to the reduction of waste generation, waste classification at source and the possibility of sorting the wastes to recycle them. Also, innovation in productive processes, improvements regarding the optimization in managing different kinds of enterprises, the defense of consumer rights and personal rights, and improvements in the finances of SMEs, among other actions, contribute to a significant improvement of the city’s sustainability. This is one of UCEL’s goals, not only at its headquarters but also at its different branches in the region.

- Responsible Consumption and Production

Goods and services production must be destined to their rational use and to avoid superfluous products and wastage. Satisfying social needs implies having a clear understanding of what is important and what is accessory. One of the major environmental problems studied at the “Environmental Management Specialization” (EGA), a postgraduate degree in UCEL (view section 4.2.1), consists precisely in analyzing what are the basic requirements of current societies in order to avoid consumerism, which causes a waste of material and energetic resources. This sobriety culture is found in the whole of UCEL’s academic offer because of its ethical and economic importance.

- Climate Action

GHG emissions have generated a rise in the planet's average temperature with unpredictable consequences. UCEL was the first university in the country to measure its Carbon Footprint in 2018, aiming at reducing it from year to year. For this purpose, all activities of the headquarters were taken into account, as well as its employees' means of transport and the energy consumption of air conditioners, heating equipment, computer system, etc.

- Life Below Water

Due to its location, UCEL contributes to upgrade the quality of the city's waterway, the Paraná River. Every year, different teams clean up plastic waste thrown into the river, picking up a ton of trash per working day. As it is well known, plastic micro particles have been found inside the digestive system of the Paraná fish. This is caused by people's negligence, because they throw away plastic bottles instead of reusing them or throwing them in authorized places. It is clear that this plastic follows the trophic chain and ends up in the human body by fish intake; that is precisely what UCEL tries to avoid.

- Life on Land

Life on the land in which the University is located is permanently monitored, preventing soil contamination in its Pilot Plant and in every place where UCEL's educational community performs their activities. UCEL conducts environmental assessment studies in the Plant in order to verify that the activities do not deteriorate the water, air and soil quality. UCEL's effluent plant guarantees that the agricultural-industrial environment where it is located is not polluted.

- *Peace, Justice and Strong Institutions*

Peace and justice are also evaluated in the human relationships of UCEL's employees by the Departments of Human Resources and Student Welfare. Congenial work environment, conflict resolution via mediation and the presence of a university pastoral contribute to achieve this goal. The institution's strength is observed in the increase of the educational offer, in its significant presence in society and in the development of applied research with a regional focus.

- *Partnerships for the Goals*

The current complexity of higher education has led UCEL to make alliances with similar institutions in university networks that enable to join efforts and enhance institutional synergy. One of these networks is Argentinian Universities for Environmental Management and Social Inclusion Network (UAGAIS in Spanish), which allows to boost sustainable management in Argentinian universities, provide tools for its evaluation and communicate the best practices regarding university sustainability.

UCEL's Actions to Achieve SDG 12: Responsible Consumption and Production

Responsible production

UCEL, through its Food Technology Engineering degree (ITA in Spanish), has always worked on quality improvement of food production processes, on the optimization of these processes' productivity, on the rational use of energy and on the care of the environment surrounding the production plant. That is to say, UCEL has worked on CP and EE since its beginnings. These concepts, essential in the training of the Faculty of Chemistry students, enable graduates to have specific training regarding environmental care in general, beside specific engineering training.

For ITA students to have an appropriate and technologically equiped place for their practices, UCEL built a Pilot Plant of Vegetable Oils where CP, EE and environmental care could be applied in the production of edible vegetable oils. The Plant characteristics and the products are described below.

The UCEL-ASAGA Pilot Plant of Vegetable Oils is located in National Route 9, 335.5km near San Jerónimo Sud, in the province of Santa Fe. It is a joint undertaking between UCEL and the Argentinian Association of Fats and Oils (ASAGA in Spanish) for research, training and development in the industrial production of fats and oils of vegetable origin.

The Plant, inaugurated in September 2016, is focused on the extraction of oils and fats of vegetable origin. Extractive processes and further processing of the obtained flours for its use for food purposes, both for human beings and animals, are studied. Moreover, just like flours, extracted oils and fats can be subjected to special processes, such as refining, with the objective of adding value and broadening their possible uses for food and industrial purposes.

Located in the world's most important oil-production and oil-processing core, the Plant is set in an agro-export model country, in which active policies must tend to favor a diversified and federal development with value added and product use in its place of origin, and to counteract long decades depending on the exportation of low or non-value-added raw materials. In this context, science and technology agencies, universities, the National Institute of Agricultural Technology (INTA in Spanish), the National Institute of Industrial Technology (INTI in Spanish), ASAGA, all have a strategic role in the regional scientific and technological development and in the training of skilled human resources. The Plant industrial characteristics make it unique not only because of its automation and technology level, but also because of the associative conception of its development, that is to say, due to its double-sided nature: university and entrepreneurial. In this regard, in order to build this Plant, UCEL and ASAGA collaborated in academic, technical and scientific assessment. The fusion of two high-level institutions such as UCEL and ASAGA materializes the performance of competitive research and development activities on the basis of laboratory tests and at pilot plant scale. There is also an effort to involve regional and provincial governments so they see the Plant as a reference point for the improvement of agro-food industrial processes.

This Plant seeks to be the starting point for strengthening the knowledge of the future UCEL graduates. It is focused on the academic training of specialists and on developing technological innovations available for their implementation in all enterprise groups belonging to the sector of fats, oils and derived products with industrial and/or food use. It allows to enrich and enhance Research and Development (I+D in Spanish) entrepreneurships as well as to promote the generation of new techniques that aim at improving methods and processes and reducing processing plants' production costs. It seeks to apply new technical and scientific knowledge, and also to introduce conceptual shifts in products, processes and/or organizational forms with a significant impact on the economy of oil-sector companies, e.g.: improving productivity, reducing costs, moving towards the opening of new markets, creating appropriation forms of the benefits of technological innovation, promoting environmental awareness related to the Plant effluents treatment, etc. Research and development activities allow the validation of new processes and prototype products that can be applied later at industrial scale, providing technical and economic benefits with great impact on regional industry. In the Plant, the procedures are similar to the ones developed in industries which elaborate edible fats and oils (15).

Regarding the definition, organization and execution of Research, Development and innovation (I+D+I, in Spanish) complementary lines, the activities in the Pilot Plant have a positive impact on the productive sector, an impact that will be seen in the medium and long term and that has a huge potential in terms of value addition. The Plant works to identify I+D+I lines to achieve innovation in products and processes, and to establish and develop priority lines.

In addition, the Plant has been built with extremely high safety ratings, it satisfies the most demanding environmental requirements and it holds technologies to reduce energy consumption to the minimum possible (4).

Picture 1: Panoramic view of the UCEL-ASAGA Pilot Plant of Vegetable Oils

Picture 2: Panoramic view of the UCEL-ASAGA Pilot Plant of Vegetable Oils (detail)

Pilot Plant's operation

Preparation Sector

The goal of this sector is to produce the seed physical transformation in order to prepare it for the solvent extraction process (hexane).

The seed is unloaded from a truck into a reception silo of about 6 tons of capacity. Via transport, the seed is sent to a first cleaning stage. This stage aims to remove remnants of solids and impurities present in the seeds by using a sieve. In turn, there is a magnet system that retains or prevents the passage of solid metal particles that may damage the subsequent equipments' performance, mainly breaking and laminating machines. Impurities are gathered in an appropriate cart. The cleaned material is then sent to a hopper-scale that allows to calculate the volume of processed seed.

The next stage involves size reduction through a breaking machine, which produce greater surface contact in the seed for further operations and detaches the shell, making its removal easier. The broken seed together with the shell is then transported to the cooking stage. On the way, if eliminating the shells is wanted (as these have a lower specific weight), they can be dragged down through a vacuum using a fan-generated air stream, after passing through a cyclone which divides two streams: upper stream: an air stream with 20% of relative humidity (eliminated to the atmosphere) and lower stream: solid shells and impurities.

Picture 3. Sector and entrance sign to the plant.

With the use of a cooker, the cooking stage allows conditioning through the application of heat and rising material temperature up to 60º C. This procedure is carried out by the indirect application of high-pressure water steam (7-8 barg). This heating denatures the proteins that form cellular walls retaining the oil and diminishing oil viscosity due to temperature effect.

The following stage, lamination, allows to break oil-bearing cells, whose effect enhances oil exposition for ulterior extraction. These sheets must have a thickness of about 0.28 y 0.4 mm, depending on the material being processed.

Using an expander, the previously formed sheets are expanded to create a more permeable material with a certain porosity that enhances the subsequent extractive process. In order to achieve this, direct high-pressure steam is injected, which in turn provides certain humidity. Within the equipment, temperature varies between 105-108º C.

In order to store the material at a suitable temperature, a cooler machine, which allows material cooling through a cross-air stream, is used.

If processing high oil content seeds is wanted, the process may be different after lamination and breaking. An extrusor can be used to condition, raise the temperature and prepare the material for pressing by applying pressure.

This extruded material goes into a press. As pressure increases, the product releases heat; on one side, it secretes oil and, on the other side, the filter cake is detached. This heating, in addition to the exerted pressure, not only diminishes oil viscosity, allowing more fluidity, but also eliminates water, drying the product. This pressed material must be cooled down using a cooler machine.

Air streams with a high relative humidity content (60-70%), then eliminated to the atmosphere, are vacuumed by a fan, after passing through a cyclone.

Picture 4. Sector of silos for seed collection.

Extraction Sector

The goal of this sector is to reduce the content of oil within the sheet, expanded or expeller to the minimum possible with the minimum hexane consumption.

The specially-treated material coming from the preparation goes into an extractor. This equipment, central in the process, provides enough contact time between the material and hexane in order to extract the oil. Hexane, before being put into the extractor, is preheated with an exchanger.

Basically, there are different stages in this operation:

1) soaking: the material is soaked in the liquid so it enters the washing stages impregnated with hexane or miscella, because:
   - soaked material has a lower density than wet material, in the latter case the extractor's capacity would be misused;
   - the material gets greater homogeneity, which improves the extracting process. Being impregnated with hexane or miscella, the formation of preferential circulation flow channels is avoided;
   - it diminishes air intake within the system, which improves the recovery process and reduces hexane loss with steams;

2) washing: hexane and miscella (irrigations) circulate through the material to perform the extraction strictly speaking;

3) draining: hexane from the last wash is left to drain so that flour has the least amount of hexane possible.

Miscella (oil + hexane) passes through a fabric to get filtered before leaving the extractor and getting directed to the distillation stage. A hydrocyclone allows to separate and recirculate into the extractor solid particles that might get dragged together with miscella and would obstruct the distillation equipment.

On the other hand, solid material is unloaded into a hopper and directed to the desolventizing stage. This extracted material is soaked in hexane and transported into a desolventizing-toasting machine**.** Inside this equipment, a first pre-desolventizing is conducted by means of flour heating, in which hexane gets eliminated using indirect heating and a direct steam injection as a conveying element. 99% of the hexane elimination is done in a relatively easy way and in a short time; the remaining 1% presents difficulties. The injected steam homogeneously produces the desorption effect of hexane in the flours. The purpose of this pre-desolventizing is to achieve an adequate humidity level in the flour for a proper toasting. The direct steam, together with the eliminated hexane, is directed to the atmospheric condensation stage.

The desolventized flour (about 300 ppm of hexane) is unloaded by a rotary valve that keeps the material sealed. This flour is taken via transport into a hammer mill in order to reduce and homogenize its size, and then goes into a strainer, after being transported into a storage silo.

Distillation

Oil leaves the extractor with the solvent (approximate oil concentration: 25% p/p), which must get separated. This separation, via evaporation, is done in the distillation.

Miscella is then taken into a buffer tank and from there, after passing through a filter bag to retain solid waste, is pumped out into an evaporator, subjected to an absolute vacuum of 300 Torr and indirectly heated with a saturated water steam of 4 barg. On this stage, most of the hexane from the miscella is eliminated. Evaporated hexane is directed to the vacuum condensation stage, while miscella is pumped out to a stripper in order to eliminate the rest of the hexane and increase its oil concentration. This column has internal trays where the fluid circulates, and from the bottom of it direct drag steam is injected. This equipment, like the evaporator, is subjected to a vacuum of 300 Torr.

The evaporated hexane together with the stripping steam is sent to the vacuum condensation system, while the oil without hexane is led to the degumming stage.

A safety tank has a volume capable of restraining the distillation equipment, in case of a potential leakage or an accidental breakage of them.

Degumming – Drying

The oil coming from the stripper is in-line mixed with hot water in order to remove hydratable gums (phosphatides). The mixture becomes more efficient when circulating through a static mixer and then it is directed into two reactors to complete the required reaction time. After reaction, the oil together with the gums are sent to a centrifugal separator that separates the oil from the gums by centrifugal force. The gums are retrieved in an appropriate container while the degummed oil is led to a buffer tank. From this tank, the oil is vacuumed out into a dryer, which is subjected to an absolute vacuum of 80 Torr generated by an ejector. An oil sprinkling is generated inside this equipment, which allows to eliminate retained water after degumming and hexane traces dragged from previous stages. Entering the dryer and in order to achieve a proper elimination of this water, the oil is heated indirectly by a steam of 4 barg with a double-tube exchanger.

Before sending the finished oil into stock tanks, it must be cooled down indirectly by water up to 40º C to avoid its deterioration. To this end, a plate cooler is used.

Solvent Recovery (hexane)

The gas streams coming from the evaporator, the stripper and the ejector are sent to a condenser which allows, by indirect contact with water, to condense these hexane and water gases. Inside this equipment, there is an absolute pressure of 300 Torr generated with an ejector.

Condensed fluid is then sent into an hermetic tank, from which it is pumped out to a decanter.

On the other hand, the gases coming from the toaster and from the vents of all the atmospheric equipment is sent to the atmospheric condensation system that is comprised of a condensator and uses water in indirect contact to this end. The condensed stream is directed to a decanter. Because the streams that enter this decanter are basically composed of hexane and water, an adequate residence time allows to separate both fluids and get hexane in good conditions to be reused. The water that comes off from this equipment is directed to a boiler in order to extract the hexane, which is drawn by the water streams into the decanter. The ejector's motive steam enters this boiler, which allows to increase the mixture's temperature in order to evaporate the hexane. At the same time, it is provided with a direct steam line in case it is necessary to add energy to the mixture. This equipment's output water is sent into a solvent trap in order to keep and accumulate hexane. The trap's water output has a flow speed of about 300 kg/h and contents about 20-30 ppm of hexane, and it is an effluent liquid stream.

Regarding the mineral oil circuit, the rich-in-hexane non-condensable steams that come from the atmospheric condensation system are sent into an absorber, in which they are put in contact with mineral oil. As the gases go up the column, the hexane is absorbed by this oil, whose temperature must not exceed 32º C approximately. The drawn air and hexane traces that are eliminated by the column's dome are sent to a flame arrester before being vented to the atmosphere. The hexane concentration of this gaseous mixture is of about 25 g/m^3.

The mineral-hexane oil miscella that comes off from the absorber is heated with indirect steam in a heater, before entering the stripping column, in which direct steam is injected on the bottom and the mineral oil's hexane is eliminated for its reuse. The column operates in a 300 Torr vacuum and, as mentioned earlier, the gases in the dome of this column are sent into a vacuum condenser while the oil is cooled down using a cooler in order to enter the absorber through the upper part and close the circuit.

Tank yard

In this yard there is a tank for the vegetable oil finished in the degumming-drying stage. The pipes connected to this tank allow the oil to be sent to future refinery or to be loaded in a truck. Another tank is available to receive dry, but not degummed, oil. The idea is to accumulate material in order to use the centrifuge properly, since this machine has spare capacity for the Plant's nominal operation flow. A third tank is used for lodging pure solvent.

Raw materials for the operational stage

The required raw materials used in the operational stage are: seed, flour, miscella, oil, gums, hexane and water.

Environmental Management Plan

UCEL's strong commitment to environmental care made it essential to study the Pilot Plant's activities' possible negative environmental impacts. For that purpose, an *Informe Ambiental de Cumplimiento* [Environmental Report of Compliance] (Coria, 2010) was prepared. This possible qualitative and quantitative impacts were studied by using the Leopold matrix (cause and effect). Values were agreed in an interdisciplinary way, identifying the critical points in order to enhance desirable effects as well as to mitigate the undesirable ones, and to establish a general plan and programs of protection and conservation of the Pilot Plant environment.

The criteria established at the moment of the matrix confection are maintained and upheld on equal terms, which implies that future improvements or modifications to the Plant can affect positively or negatively the considered values. This would imply the revision of each program of the Environmental Management Plan.

The Environmental Management System (EMS) includes the Environmental Management Plan (EMP), which provides the foundations to establish the Environmental General Policy and Strategy of a Plant like this. Thus, environmental issues are made compatible with political, socio-economic-financial, technical, commercial, cultural and social decisions. The EMS application is limited to preventive approaches in order to evaluate in advance activities that could have negative environmental impacts, to foresee these impacts and how to eliminate them, and to strengthen positive impacts to the system and the Plant itself.

The goals of the EMP are to consider a series of guidelines and strategies intended to comply the environmental objectives preset by the Plant's authorities. These guidelines seek to ensure that the economic, financial and technical decisions are environmentally rational, effective and sustainable over time.

On the other hand, UCEL's Environmental Policy implies the application of an EMS which must be integrated to other University projects and must be able to manage in a proper and sustainable way the negative impacts this activity could potentially generate during its lifespan. The Plant complies the current provincial and national environmental legislation, and is prepared to comply international requirements as well.

The EMP is evaluated annually, and Monitoring Programs are designed to be performed every three years or less if necessary. The professionals in charge keep records of the values obtained and their tendencies is verified in order to generate statistical information.

With this Plant, included in UCEL's institutional strategic plan, the University clearly assumed a key role of high education institutions: achieve a significant transformation in the surrounding reality.

Nowadays, as stated above, it is fundamental for the University to go out of the Academy and share concerns, common goals, human and material resources together with social and institutional actors, in order to propose agreed and concrete solutions for regional problems that nobody can solve on their own or without the interdisciplinary approach required by the complexity of present times. Thus, this Plant enables the complementarity between the University and enterprises, in an attempt to develop solutions to actual environmental problems.

Responsible production implies not only environmental care, but also the application of the necessary technology to convert sub products into high nutritional value products. In Rosario there are many people below poverty line, and, therefore, they only have access to a poor and bad nutrition. After the construction of the Pilot Plant of Vegetable Oils, as a next step UCEL created the first Technological Platform of Vegetable Oils and Protein Extraction Valorization, together with the companies Bioceres S.A. and Arcor S.A.. The Platform's goals are:

- creating the necessary technical infrastructure at pilot scale in order to achieve an integral cycle of development and valorization of extraction proteins and vegetable oils, derivatives and sub products from native crops. This implies the installation of a plant for protein concentrates and isolates, texturizing, bio-refining, etc.

- developing new value-added products centered in the integral valorization of extraction proteins and oils, for export and/or import substitution, prioritizing technological innovations on agro-food, bio-energy and biotechnology of the waste and sub products generated in the process;

- offering high technology services to meet the demands of the National Innovation System as well as agro-food and agro-industrial companies interested in the economic valorization of extraction proteins and oils, derivatives and sub products;

- formalizing strategic I+D partnerships with actors from the scientific-technological system and the food production sector in economic valorization projects regarding proteins, derivatives and sub products.

The first part of this project, which implies grain grinding and separating its components in oils, fibers and proteins, has already been carried out. The Pilot Plant of Vegetable Oils is at the integral service of the requirements of the National Innovation System and Argentina's agro-food and agro-industrial productive sector.

Responsible consumption

Although the ideal situation would be a change in the development model to reduce the problems regarding responsible consumption mentioned in the introduction, until this goal can be achieved, higher education institutions must work responsibly and vigorously in the solution or mitigation of the harmful effects caused by current processes. To this effect, a previous, in-depth analysis is required in order to get a clear vision of our conducts and how we jeopardize future generations, infringing upon the very concept of SD.

UCEL has different strategies to promote responsible consumption. In this respect, we will first describe the aforementioned "Environmental Management Specialization" (EGA), a postgraduate degree dedicated to provide environmental care training and skills to propose solutions to environmental problems, and then other UCEL concrete actions related to air, soil and groundwater contamination and directed by the author of this chapter.

Environmental Management Specialization (EGA)

UCEL's academic offer shows excellence in all of its graduate and postgraduate degrees, providing the students the skills they need to make a balanced synthesis between the best practices and the theories sustaining them in their professional performance once graduated. This is UCEL's premise at the moment of planning and materializing its educational offering for future professionals, which play a central role in the region's sustained growth and development.

Rosario, center of the influence area of UCEL, is by tradition an important industrial and commercial region, and it is part of the country's most important productive corridor, which stretches from the city of La Plata, in the province of Buenos Aires, to Puerto San Martín, in the province of Santa Fe (a few kilometers away from Rosario). The city represents the central core of an urban conglomerate known as Metropolitan Area of Gran Rosario, with an approximate area of 580 km^2 and with a population estimated at 1,070,000 inhabitants. This area gathers 42% of the industries, 53% of the employees and 62% of the production of the province. In this way, it is an industrial, commercial and financial center settled in the very heart of the country's most important agricultural and livestock productive region, known as Pampa Húmeda. In turn, the province of Santa Fe is one of the most prosperous regions in the country; its geographic location, its natural environment and its harbors can be pointed out as factors that have always favored its development.

The region's characteristics, added to the last decades' technological development, have generated serious environmental deterioration problems. With the "Environmental Management Specialization" (EGA), a year-long postgraduate degree, UCEL intends to contribute on solving the country's environmental problems in its legal, institutional and economic contexts, bearing the social responsibility it has with the region and the country, and contributing to high level professional training in environmental sciences.

This degree was created to fulfill an unsatisfied educational demand of professionals who work in production or services companies or audit offices, and the ones who are in charge of developing and implementing environmental assessment studies and environmental management systems or plans. It also allows to offer a professional specialization in cross-sectional studies related to environmental management, a field of study in increasing development. Besides, it intends to satisfy the specialization demand regarding the resolution of the region's different environmental problems by training professionals who will be able to work in public organizations, as well as in industries, academic institutions or social organizations.

EGA first started in 2013 and was accredited by the National Commission for University Evaluation and Accreditation (CONEAU in Spanish, a decentralized institution that operates under the jurisdiction of the National Ministry of Education). EGA's main objective is to give an academic and professional training that provides conceptual and methodological competences and skills for the management of environmental resources, based on the analysis and understanding of the political, social, economic, administrative, legal, organizational and instrumental aspects required for the application and evaluation of environmental policies. This objective is focused on the needs of the region, its particularities and the aspects related to the urban environment of major cities and to the rural environment.

The specific objectives of EGA are: a) training specialists with a clear conscience about the importance of natural resource management, the dynamics of the relations between the State, society and nature, as well as the context in which they develop and the processes involved; b) providing knowledge and competences for the conceptualization and the empirical analysis of the organizational dynamics and the process of the environmental management system formation; c) developing skills regarding the use of the most technologically advanced tools applicable to environmental management; d) developing competences in different environmental management methods and techniques; e) relating environmental policies to SD policies; and f) developing activities that promote the students' analytical, critical and creative skills and collaborative work in multidisciplinary teams.

Generally, students are professionals graduated from different five-year university degrees, who work in companies or public organizations related to environmental problems.

Regarding the degree's teachers staff, in UCEL there are local, national and international prestigious teachers, professionals and academics, with an extensive and renowned career in environmental management. Its Director is the author of this chapter since its creation. An Academic Committee is in charge of the students' supervision.

The graduates of EGA are able to: a) identify, evaluate and analyze activities aimed at preservation, correction and remediation of problematic environmental situations; b) suggest and implement solutions to detected environmental problems; c) design environmental management programs that achieve an optimal use of natural resources; and d) perform environmental assessment studies.

The degree is divided into eleven modules; the approval of all of them is a mandatory requirement to submit the Thesis. The modules have horizontally and vertically articulated thematic axes. The transversal axis is the application of management processes to solve environmental problems generated in productive or services enterprises, or problems that must be addressed by public organizations. These modules are: Ecology, Sustainable Development, Environmental Chemistry, Environmental Management, Environmental Legislation, Environmental Assessment Study and Evaluation, Environmental Policy and Regulation, Effluent Management, Energy and Environment, Industrial, Urban and Hazardous Materials, and Statistics. The Thesis is a real research work, monitored by the teacher in charge; the future graduate must demonstrate his/her ability to address problematic situations rigorously and independently. The final evaluation involves case resolutions where the acquired knowledge must be integrated.

Air pollution

Globally, air pollution is one of the most critical environmental problems and one of the most challenging for the scientific community, which must face the problem of reducing it to permitted levels according to international laws on air quality. The best way to keep the air we breath uncontaminated is avoiding the emission of pollutant substances from their primary sources, that is to say, from the place in which they are generated. For this purpose, the best solution is the use of catalysts that retain these substances and degrade them to prevent them from escaping and contaminating the air and the environment. The author of this chapter has investigated the properties of different substances that may be used as catalysts for more than twenty years, in his doctoral thesis as well as in different research and technology transfer projects, which he has directed. Two of these projects, developed with UCEL's financial support, are mentioned hereunder.

Research Project: Study of the variation of the surface properties at high temperatures in transition metal oxides, supported in alumina, for its use in catalytic reactions which involve gases adsorption

Catalysts have a wide industrial use. The relatively low cost of the oxides, their high thermal stability and their possibility of reutilization by means of desorption with air at high temperatures make these materials of industrial interest in reactions at high temperatures, in which the catalyst efficiency, lifetime and versatility must be increased.

At present, there is very little information about the behavior of surfaces like transition metal oxides of the first period when they are subjected to temperatures between 600º C and 1000º C, temperatures which are used in industries, and when they are expected to be used as catalysts in reactions of industrial interest. The idea of using metal oxides like Vanadium (V), Chromium (Cr), Manganese (Mn), Iron (Fe), Nickel (Ni), Cobalt (Co) and Molybdenum (Mo) is based on their thermal resistance, due to the fact that they are subjected to the temperatures that are normally used in industries, and on their different properties in acid-base and surface redox reactions, besides the possible synergies between them. Mo, although it belongs to the second transition period, was included to obtain comparative results in relation to the rest of the metal oxides, which belong to the first period.

The main objective of the project was to determine the influence of high temperatures over the surface activity of supported transition metal oxides. The specific objectives were:

- Determine the variations in the surface area of the different supported oxides (Isotherm BET).
- Analyze how temperature affects the crystalline structure of the analyzed oxides (XRD).
- Verify variations in the metal-oxygen bond energy for the supported oxides subjected to different temperatures (XPS).

After the bibliographical search, the team began the laboratory tasks in October and November 2007. In these months, the salts corresponding to the different transition metals were weighed and calcined in order to obtain the oxides, and the g-alumina was calcined always at 600º C. The oxides which were obtained, supported in alumina, were sent for laboratory analysis.

The gas adsorption capacity by the surface of metal oxides depends on the strength of different types of basic centers and of the number of them on the surface. This gas adsorption capacity is function of the temperature, of the type of gas circulating and of the flow as well. In order to determine this capacity, these solids are prepared and then characterized before and after their use at different temperatures to evaluate the surface variations provoked by the exposition at high temperatures and different periods of time. This allows obtaining the best use conditions for each oxide in catalytic reactions which involve gases adsorption as a previous stage. The characterization implies the determination of BET Surface, X Ray Diffraction (XRD), chemical analysis to determine the quantity of metal on the surface (Atomic Absorption Spectroscopy, AAS) and X Ray Photoelectron Spectroscopy (XPS).

X Ray Diffraction consists in the study of crystalline structures, whereas BET Surface analysis is the measuring of the each oxide specific surface. X Ray Photoelectron Spectroscopy (XPS), on the other hand, consists in applying X radiation on the sample. This radiation is transferred to the internal electrons of the atoms present as kinetic energy. When the electrons are emitted, this kinetic energy is measured by the equipment; this action allows to know the different classes of atoms in the sample (qualitative analysis). The area under the curve in the process of deconvolution of the peaks obtained in the spectrum provides the quantitative relationship between the different classes of atoms on the surface.

In regard to the characterization of supported oxides, it was observed that the specific surface of chromium oxide is significantly reduced when the temperature and the period of time of exposition to it is increased. It was not possible to confirm if this behavior is shared by the other oxides due to technical problems of the equipment for determination of BET Surface and pore size distribution (*Quantachrome Autosorb Automated Gas Sorption*).

The analysis by AAS of the prepared oxides showed that the percentage of metal obtained in the oxide was inside the expected value (around 10 %). The analysis by XRD showed that as the treatment temperature increases, the crystallinity percentage for all the oxides also increases.

The XPS analysis showed that the bond energy for the oxide O1s increases as treatment temperature increases (531 eV at 600º C and 537 eV at 900º C). Something similar occurred with the Cr2p (577eV at 600º C and 583 eV at 900º C). This demonstrated that it is possible that there are two species, Cr_2O_3 and CrO_3, in different proportions while temperature increases, which could be due to an oxidation of the chromium from +3 to +6 in surface. This could explain the difference in XRD of the chromium oxide at 600º C with the one at 700º C and 900º C, attributable to the presence of more than one oxide at higher temperatures.

It was concluded that the transition metal oxides supported in alumina decrease their capacity to retain gases as temperature increases between 600º C and 900º C and as the treatment time increases, due to the fact that their specific surface decreases. We also concluded that there is a reduction in the pore size by crystallization, which decreases the adsorption capacity of the oxides by physisorption.

Technological Transference Project: Installation of the catalyst Cr2O3/Al2O3 in industrial chimneys – Reduction of SOx and Nox in emissions

Among the gases responsible for air pollution, the SO_2 is the most emitted pollutant to the atmosphere. The industrial processes which most contribute to the presence of SOx compounds in the atmosphere are calcination of sulphur minerals, oil refining, H_2SO_4 production and coke production from coal.

Sulphur oxides are eliminated from the air when they are converted in sulphur acid and sulphates. With this form they end up settled on land and sea, by pluvial precipitation or deposited in form of sedimentary particles.

General methods for SO_2 level reduction in gases from industrial chimneys are divided in disposable, regenerative and dry processes. As

SO_2 is an acid gas, almost all purifying processes use a watery solution or slurry of an alkaline material. The disposable designs get rid of the sulphur by eliminating it in the form of some residual mud of calcium type. The product of regenerative processes is sulphur or sulphuric acid, and the alkaline solution is recircled. In dry purifying, the SO_2 is removed by putting it in contact with an absorbent solution; this process generates compounds of sulphite and sulphate type.

The objective of this project was to investigate the possibility of reducing the level of this pollutant by means of its adsorption on Cr_2O_3/Al_2O_3 and then its reduction with CH_4, which is collocated on a metallic support in the industrial chimneys transversal sections. Based on studies made in previous research projects, it was observed that this catalytic material is capable of retaining sulphur oxides on its surface, together with the oxidation of methane and its conversion to CO_2. This chromium oxide supported in alumina has a high mechanic resistance to temperatures, and as a consequence its surface porosity (the gases are retained or adsorbed on the surface) begins to modify by the action of this parameter after 700º C. Another relevant advantage is its high adsorption efficiency and its capacity for regeneration (it can regenerate up to three times without losing its efficiency).

In the first stage of the project, experiments were made at laboratory scale using analytical quantities of catalyst and gas mass. Afterwards, the tasks were made at pilot plant scale; the necessary quantities were extrapolated to experiment on the base of a metallic column called "reaction site". This was designed at scale of the model of a sulphur acid plant chimney located in San Lorenzo, near Rosario. In the final stage, the reduction of nitrogen oxide on its surface was studied. The results were similar to the ones obtained in the study of sulphur oxides.

The aim was to demonstrate that the application of the catalyst inside the industrial chimneys that emit combustion gases reduces the SO2 emissions in a 99.9% and those of NO_2 in a high percentage (the confirmation of the removal efficiency of NO_2 depends on the application of the catalyst at real scale).

The process is highly efficient and inexpensive and it does not generate derivatives that should be treated afterwards (this reduces even more the operative costs of this technology). Besides, it is regenerative and has a long lifetime, about three months of continual use at pilot plant scale, which must be confirmed once installed and implemented at real scale. As a consequence, the plant would be in condition of complying any law regarding the level emissions of these gases to the atmosphere.

In order to achieve results at industrial scale, it is necessary to install and experiment the behavior of this catalyst in a chimney. The main objective of this technological transference project is to reduce sulphur and nitrogen oxides concentrations emitted in industrial chimneys with high efficiency, and reduce the methane emissions due to its oxidation and conversion to CO_2. It is important to remember that a CO_2 molecule has a 21 times more pollutant effect than a CH_4 molecule in the atmosphere.

This process involves a technology to reduce sulphur dioxide and nitrogen levels produced by combustion gases generated in industrial plants based on the adsorption of these on the catalyst Cr_2O_3/Al_2O_3 surface. The advantages of its application are the following:

- It is an efficient process: the results at laboratory and pilot plant scale (developed in 10 years of research) show an efficiency of 99.9 % in SO_2 retention.

- It is safe: due to the fact that it uses a catalytic support that works by means of the gas physical adsorption, there is no risk for operators who install it and monitor its operation.

- It is low cost: the approximate cost is 5 to 7 US$ a kilogram.

- Regenerative: after the surface saturation, it can be regenerated up to three times without losing adsorption efficiency.

- It does not generate derivatives which should be treated afterwards as hazardous materials.

And in the case that they are generated, it would be in very small quantities a year.

At laboratory and pilot plant scale, its efficiency was confirmed for the SO_2 adsorption in presence of other gases which can normally be found in an industrial chimney, such as CO_2, CH_4 and O_2, and taking into account other fundamental conditions, such as temperature, gas flows, dimensions of experimental equipments, etc. The SO_2 and NO_2 joint adsorption over the Cr_2O_3/Al_2O_3 catalyst, under the same experimental conditions, was also studied.

The application in an industrial chimney of the devise developed in this project is fundamental in order to study its behavior at real scale and the interaction of the designed product with the compounds and conditions present there.

Soil and groundwater contamination

Soil and groundwater contamination is one of the major environmental problems in Argentina. There are different contamination sources: industries, open-air dumps, septic wells, intensive livestock farming, hazardous substances spills, open-pit mining, use of agrochemicals, abandoned gas stations, etc. The pollution of these resources, which affects the life quality of people and the environment, is increased by production excess and the waste they generate during and after the products are consumed by the society for which they are destined, by the increasing consumption of meat, by the generation of fossil fuel energy, by the non-sustainable extraction of renewable and non-renewable resources to satisfy sumptuary needs, etc.

Hereunder, we will analyze four cases of remediation of contaminated soil and groundwater; these remediations were directed by the author of this chapter within the framework of UCEL's environmental activities and funded by "La Segunda CLSG" Insurance Company. Remediation is the set of corrective operations destined to avoid the harmful effects that a contaminated soil causes or could potentially cause. Appropriate measures must be adopted to restore the altered physical situation or to prevent new risks for people or damages in goods or the environment. The technology remediation choice must be based on the results of previous environmental studies performed in the site. As a first measure, the pollution source must be eradicated, and then the remaining pollution must be eliminated or neutralized, in order to eliminate the risk it represents to people's health and to the environment. Naturally, the purpose of a remediation is to achieve that remaining values of soil and groundwater pollutants are inferior to the ones established by the current legislation, that is to say, to restore the natural conditions of the environment, reducing the concentration of pollutants to an acceptable limit. In order to optimize resources, analyze the intrinsic effects of the remediation process and evaluate the progress of the tasks, it is necessary to control and monitor the systems.

Soil remediation in an abandoned gas station contaminated with hydrocarbons in the city of Rosario, Argentina

In a case of soil contamination by hydrocarbons there are three alternatives, taking into account the behavior of crude oil and its derivatives in soil: a) not remediating the contaminated soil, b) containing or isolating the contamination, and c) remediating the contaminated soil (by in situ or ex situ treatment). In the first case, the decision implies that the land use must be changed, the affected area must be perfectly delimited, and monitoring must be done to ensure that third parties are not harmed. The second alternative consists in establishing correct safety measures to prevent pollution progression and mitigating adverse effects caused by the dispersion of pollutant substances. Isolation can be used to reduce volatilization, to avoid the creation of leachates or the infiltration in phreatic layers. Finally, the contaminated soil is recovered or remediated by different technologies.

Cleaning techniques of a soil contaminated by hydrocarbons can be classified in *in situ* treatment techniques (the elimination of pollutants on the ground, without the removal of the soil) and *ex situ* treatment techniques (the soil is transferred to other facilities for its treatment or confinement). The first ones have the advantage that can be applied to different situations and have competitive costs, but the disadvantage is the existence of a degree of uncertainty upon their actual results. The second ones have the advantage of being effective, a better process control can be made and they are independent of external factors, while their disadvantage is that they have a higher cost.

Gas stations have buried tanks that contain remnant of hydrocarbon. Corrosion deteriorates these tanks, and as a consequence they produce soil and groundwater contamination. When someone wants to construct a building on this type of ground, there must be no environmental liabilities there. Environmental liabilities are the waste that remains in the soil after human activities that are no longer carried out.

A soil and groundwater characterization study was requested in order to evaluate the existence of environmental liabilities and implement remediation tasks, in accordance with current legislation. Naturally, before the diagnosis, the buried tanks were removed and sent to an authorized processor for their cleaning and later scrapping.

The site was previously affected to liquid fuel selling operations and abandoned for more than five years. It was located in the city of Rosario (Argentina), in an urbanized area with an average population density and a mixed urban typology (commercial and residential). The area had running water and sewer services, so there was not catchment of groundwater for human consumption. The soil profile featured a brown-colored sandy-clay texture over a sandy-loam material, whose color varied from greyish brown to dark grey. The soil's medium porosity was taken into account when carrying out the treatment, which allowed to extract the hydrocarbon gases coming from the soil by vacuum extraction (Soil Vapor Extraction – SVE method).

All of the tasks were developed according to operation standard processes established by national and international regulations (ASTM, IRAM, among others). For analytical determinations, methods defined by USEPA, ASTM or other internationally accredited regulations were used. A strict protocol was followed in order to ensure the sample preservation. The protocol was based on the samples monitoring by using Chains of Custody (CoC), which ensured their inviolability until their arrival at laboratory. According to what is exposed in the RG-14/PST technical provision of the TNRCC (Texas Natural Resource Conservation Commission – Petroleum Storage Tank Division – Soil and Groundwater Sampling and Analysis), the following compounds or compound groups were defined as Compounds of Interest (CoI), based on their high toxicity degree:

- GRO (Gasoline Range Organic Compounds) + DRO (Diesel Range Organic Compounds): Total Hydrocarbons – Hydrocarbon Range Content
- GRO-DRO (Gasoline-Diesel).
- TPHs: Total Petroleum Hydrocarbons.
- BTEXs: Benzene, Toluene, Ethylbenzene y Xylenes.
- PAHs: Polynuclear Aromatic Hydrocarbons.

Three areas were studied, with exploration lines at a distance of 0.5 m to obtain a proper resolution. 12 soil explorations (representative sampling) were performed considering a maximum depth of 5 m. Soil samples of 1 m, 3 m and 5 m were extracted from each one of them (slightly above the phreatic level). Besides, an up to 5 m deep exploration was made in the tanks zone, obtaining a total of 37 soil samples. Soil explorations were made with mechanical drilling rigs. The samples were extracted by german-type boreholes, properly decontaminated before taking each sample (a soil sample extraction equipment with a helical-shaped tip for drilling, with 1 m long coupling bars, was used). Soil samples were put in disposable plastic trays and they were bottled in glass jars with metal lids (with aluminium foil as insulator). They were remained refrigerated until their arrival at laboratory for analysis. Six of the explorations were deepened for subsequent piezometer installations. These were made up to 2 m below the static level of the phreatic layer, which was found at an average depth of 5 m at the time of the operations. A reinforced PVC piping of 63 mm was used for the slotted part and for the blind part. The slotted pipe, with a polyester mesh filter, was extended from the bottom of the well up to 2 m above the estimated static phreatic level at the time of the perforation, while blind piping with the same diameter was used for the upper part. In the annular space formed by the well wall and the slotted pipe, selected gravel of 1 to 1.5 mm diameter was collocated as a kind of filter. In order to prevent superficial water infiltration through the space between the pipe and the perforation, fine sand, bentonite and cement were used to seal the gravel filter. The piezometers were finished by closing their upper holes with PVC hermetic lids. Finally, pavement boxes were installed to protect the premises. The next step was piezometers' cleaning, extracting four times the volume of water contained in each well.

The characterization study of the soil and groundwater contaminated with hydrocarbons allowed us to know that the volume of the remnant affected soil on the spot was approximately 200 m^3. According to the analyzed samples, it was concluded that the area was dangerous for residential use. Therefore, it was declared as “a site where it was necessary to carry out remediation tasks”.

According to the values indicated in the New Dutch List (NDL) (2000) as concentration limits of analytes derived from hydrocarbons, it was observed that the 4 to 3 m deep exploration and the 6 to 3 m deep exploration exceeded the maximum values permitted for TPH in soil. The rest of the explorations made at different depths showed values within the standard. The PR 03 and PR 08 piezometers exceeded the maximum values allowed for TPH in water. The rest of the piezometers showed values within the standard.

The proposed method for soil remediation consisted in an *in situ* technique, due to its low contamination rate. Different drillings were made on the detected spots, up to 5 m deep, for chemical oxidation with H_2O_2 (hydrogen peroxide in low concentrations), to produce the degradation of pollutant materials. Hydrogen peroxide is a chemical compound that decomposes in water and oxygen, both non-toxic products. Chemical treatment allows to reduce contamination in very short periods of time compared to other technologies, and to achieve a clean soil. The oxidation with H_2O_2 is made with an alkaline pH (8,3). This requires an addition of hydrated lime to the soil and the lime mixture with the soil, or injecting the dissolved lime through the existing wells, in order not to remove the soil under the concrete layer of the gas station. Likewise, the SVE technology, Soil Ventilation or Vacuum Extraction, was used. This is a method reduces the concentration of volatile components adsorbed in soils in the unsaturated zone. With this technology, all the vapors generated by the soil oxidation can be extracted. This procedure consists in applying vacuum through the extraction holes in order to create a pressure/concentration gradient that induces the removal of vapor-phased volatiles from the soil by means of production wells, an appropriate treatment on surface and emissions to the atmosphere.

Two months after the beginning of the tasks, soil samples (and their subsequent analysis in a laboratory) were taken in order to verify the achievement of the remediation's general objectives. Control of the remediation tasks was made for six months. Later, a new sampling was carried out, with its subsequent analysis in an authorized laboratory.

As regards the *in situ* groundwater remediation, given the presence of dissolved hydrocarbons in the phreatic level water, new extraction wells were drilled, generating a depression center to extract the contaminated water for treatment. The extraction wells (piezometers) were made with a "Solid Stem Auger" drilling equipment, which can dry drill without disturbing the material to be collected or the local aquifer. The system used to build the piezometers works without the injection of any type of fluid, since not only the injection of water, but also of air, produces alterations in the original condition of the medium to be sampled. The introduction of any liquid volume into the aquifer might produce a displacement of the hydrocarbons in forms of free phase or dissolved phase that could be present in the medium, resulting in a false negative. Moreover, at the time of drilling into the aquifer, no "foreign material" (drilling mud) is altered or incorporated into the aquifer, altering the aquifer itself and/or possible contaminants in different phases. The piezometers were constructed in accordance with ASTM D 5092-90 (Standard Practice for the Design and Installation of Groundwater Monitoring Wells in Aquifers). Likewise, water samples were extracted using control piezometers in order to verify the decrease in water contamination. The contaminated water is extracted by a submersible pump and it circulates to the plate separator (capable of separating the Non-Aqueous Phase Liquid, NAPL, if any). The water then circulates up to a water separator. The separator is a three-staged equipment, designed to separate and extract non-emulsified hydrocarbon, solids and air trapped by oily water. The system consists in three stages for the separation process of oily water into a single cylindrical vertical container, subjected to pressure/vacuum. The stages include: 1) the separation by density difference between hydrocarbon and water, and the reduced flow speed of the affluent, 2) the coalescence of the hydrocarbon running over a matrix of parallel corrugated plastic plates, 3) the coalescence of small residual droplets of hydrocarbon is obtained by their passing through a steam separator device (demister) of polypropylene foam. This design provides the most effective and efficient way of separating hydrocarbon from water, because the separation devices, the parallel plates and demister are non-consumable. The recovered hydrocarbon was stored to be transferred to final disposal by an authorized vehicle. The water that was collected from the third stage was tested *in situ* with a hydrocarbon-content meter that was incorporated on the separation equipment, generating "pass" or "no pass". Samples of the treated water were taken during the procedure and they were sent to an authorized laboratory for analysis. Control was made for six months in order to verify the effectiveness of the performed remediation tasks. After this period, a new sampling was carried out with its subsequent analysis in an authorized laboratory.

After approximately two months of soil remediation tasks and just starting the groundwater remediation tasks, a scheduled control sampling (first monitoring) was carried out to define the site's situation. For this purpose, 5 soil explorations were made considering a maximum depth of 5 m. Soil samples were extracted from each one of them at a depth of 3 m and 5 m (slightly above the phreatic level, as it has been stated). The location of the explorations was defined according to the characterization study in the areas where greater contamination had been detected. The soil explorations were made with mechanical drilling rigs (PVM 6000 Helix hole digger with helical coupling bits), up to the established depth. The samples were extracted using German-type boreholes, properly decontaminated before taking each sample. Soil samples were put in disposable plastic trays and they were bottled in glass jars with metallic lids (with aluminium foil as insulator), and remained refrigerated until they were carried to the laboratory for analysis. Then, groundwater samples were taken from the same piezometers characterized in the characterization study, and they were bottled in glass jars and refrigerated. Finally, the leveling of the monitoring well was carried out. Besides, a sample of the treated stored water was taken, before being disposed in the roadside. To ensure the preservation of the samples, a strict protocol was followed. The results of this first monitoring showed that the obtained values for Benzene, Toluene, Ethylbenzene y Xylenes (BTEX) and the Polynuclear Aromatic Hydrocarbons (PAHs) in soil were within the standard; but this was not the case of the Total Petroleum Hydrocarbons (TPHs). The concentration values of the evaluated CoI in groundwater did not exceed the established values. The liquid effluent samples showed that the values did not exceed the required guide level for its spill on the roadside.

The next steps were: steam extraction and hydrogen peroxide injection (in low concentrations) and superficial water recovery tasks. Superficial water was treated by the separation equipment and then spilled into the fluvial channel. At the same time, a sample of the gaseous effluent was taken at the entrance of the activated carbon filter and in the chimney tube exit to verify the efficiency of the filters and the evolution of the remediation tasks.

Two months after the first monitoring, the closure sampling was made with 5 soil explorations for taking samples at different depths, up to a maximum of 5 m (second monitoring). From each one of the wells, 1 m, 3 m and 5 m soil samples were extracted. The location of the explorations was defined according to the characterization study in the areas where greater contamination had been detected. Then, the leveling of the monitoring wells was performed, and 15 water samples were taken from the piezometers characterized in the initial and control monitoring; 2 additional piezometers were added. According to the results obtained in this second monitoring, all the soil samples showed that the concentration values of the evaluated CoI did not exceed the established values. The same happened with the groundwater samples. Liquid effluent samples showed that the values did not exceed the required guide level for its spill on the roadside.

Then, equipment was disconnected and removed. All the exploration wells built during the remediation tasks were sealed, only keeping the wells covered with hermetic PVC lids and sealed with pavement boxes for protection. The final disposal of the gathered soils (because of the drilling) and the activated carbon used by the steam extraction equipment was carried out in plant, via authorized transport.

Six months after the soil and groundwater remediation, the characterization of both was performed in order to ensure the remediation effectiveness. For that purpose, a final monitoring with 5 soil explorations was conducted, with a maximum depth of 5 m. In total, 14 soil samples were obtained. Soil samples of 1 m, 3 m and 5 m were extracted. The location of the explorations was defined according to the characterization study, since they were areas where greater contamination had been detected. Explorations and sample collection were performed in the same way as in the characterization study. In this final monitoring, it was observed that the concentration values of the evaluated CoI in the soil and groundwater samples did not exceed the guide values established in the NDL. Hence, it was concluded that it was no longer necessary to carry out further remediation and/or recomposition tasks in the site.

Soil remediation in an ecological reserve contaminated with diesel-oil (Comandante Andresito, Argentina)

In September 2014, a truck that was heading from Wanda to Andresito in Provincial Route 19, in the north of the province of Misiones (Argentina), overturned due to unknown causes in the right shoulder of the road, 14 km away from Comandante Andresito town. The truck was transporting 38,000 liters of diesel oil, of which approximately 33,000 were spilled, naturally producing a hefty negative environmental impact. The spill took place within Urugua-í Provincial Park, less than 5 km away from Yacuy creek, which flows into Iguazú river. The provincial park is a protected natural area and has an extension of 84,000 ha. Its purpose is to protect the ecosystem of Urugua-í creek's basin, and to counteract the negative effects of Uruguays dam, located downstream from the park. Along with Iguazú and Iguaçu's national parks, located in Argentina and Brazil respectively, this park constitutes the largest reserve of the Paranaense rainforest. The area's climate has eased the *in situ* decomposition of the subsoil rocks (basaltic rocks), generating a soil with a high content of iron oxide, aluminium and silica.

Initial and final characterization tasks as well as the remediation tasks were carried out by "Soilkeeper S.A." company, directed by the author of this chapter.

In a case like this, there are two types of diagnosis methods for soils contaminated with hazardous materials: a) invasive or traditional methods, in which the contaminated soil is drilled and samples from different depth are extracted for chemical analysis, and b) non-invasive or electromagnetic methods: the geoelectrical method and the electromagnetic induction method (EMI), among others. In this case, both methods were used, but since the first ones (mass balances, soil samplings, monitoring) are better known, we will briefly describe the second ones.

The geoelectrical method seeks to obtain a picture of the cortex in terms of the electrical resistivity variations of the ground, both lateral and in depth. A continuous current artificial source is used, which is injected in the soil through a pair of electrodes. Potential difference measurements are carried out by another pair of electrodes, and soil resistivity is determined by electrical current measurements. The depth of penetration depends on the experimental device's geometry, the distance between the electrodes and the power source provided by the current. On the other hand, the device used in the electromagnetic induction method (EMI) consists in two coils: transmitter and receiver, separated by a constant distance, which are displaced throughout a line. Sinusoidal signals are sent and received via these coils. A primary alternate electromagnetic field is transmitted, which induces a secondary field in the soil. In the presence of a buried material, the secondary field will depend on this material's conductivity compared to the conductivity of the environment. The field detected by the receiver is the overlapping of the primary field and the induced secondary field. The depth of penetration varies by changing the signal frequency. After processing the data through computer programs, a conductivity map based on the depth is obtained. In the geoelectrical method, data modeling is easier and the obtained results are more accurate, but its application is slower and placing electrodes in the site is needed, while the application of the EMI method is faster and there is no required direct contact with the soil, but the data modeling is complex.

The latest contaminated soil evaluation techniques are based upon the ASTM E1739/95 risk analysis methodology, developed by the American Society for Testing and Materials, which is based on the risk that the chemical agents' sum of individual risks to human health and to the environment. A first evaluation is based on the comparison between the values of the individual pollutants found in the soil and the reference values, which are very conservative. Generally, the most appropriate in situ methods for the remediations of contaminated soils are: Bioventing, Soil Vapor Extraction (SVE), Chemical Oxidation (which was the method used in this case), Stabilization / Solidification. Other in situ methodologies are not applicable to road accidents because of the operational complications (phyto-remediation), the country's lack of equipment (electrokinetic separation), the lack of authorization to pressure-inject fluids (fracturing), the non-applicability to hydrocarbons (soil washing), the need of high complexity equipment (thermal treatment) and high local electric energy requirements as well as the equipment's high costs (vitrification). The chosen remediation methodology must be a balance between technical, environmental, legal and economic aspects.

In the case of phreatic layer's contamination with hydrocarbons, the most appropriate methodologies are: Air sparging, Bioslurping and Dual-phased extraction. The physical-chemical characteristics of the spilled product also influence the decision to apply one or another methodology, particularly its vapor pressure and its water solubility.

A 600 m long and 10 m wide affected area was detected on the impact zone upon the road shoulder and the loan area. The fuel spilled along a roadside located between the hill and the loan area, with a length of 170 m and a variable width of 1.5 m toward the town of Wanda. On the other side of the road, affected soil and water were found, due to the spill of the fuel across a ditch, with a length of 180 m and a variable width of 1.5 m. A surface water course was found in the area, formed by the rainwater draining ditch that is connected to Yacuy creek through a canal, which flows into Iguazú river, upstream of Iguazú Falls. In order to avoid the spread of the contaminated area and to contain the fuel spill, two landfills were built 130 m apart from each other in the area of the oil recovery well made during the emergency tasks to remove the fuel with absorbent cloth and to avoid the contamination of Yacuy creek. There were no inhabitants within a 7 km radius.

Pictures 5 and 6. Sampling tasks to study the degree and type of contamination in the Yacuy stream.

An initial characterization study of the area was made in order to determine the affected site's situation. Some spots on the canal and Yacuy creek were also characterized to rule out the spread of the contamination into Iguazú river. 24 soil samples were collected and bottled in glass jars with metallic lids and insulating aluminium foils. 7 water samples were collected and put in brown-colored glass bottles, with front and back lids. A strict preservation protocol of the samples was followed.

A few weeks later, additional samples were collected: 5 soil samples and 3 water samples. The following compounds were defined as Compounds of Interest (CoI), respectively using EPA 418.1, EPA 8015 and EPA 8270 analysis methodologies:

- TPHs (Total Petroleum Hydrocarbons)
- BTEXs (Benzene, Toluene, Ethylbenzene y Xylenes)
- PAHs (Polynuclear Aromatic Hydrocarbons)

The results of the initial characterization study were alarming. Some of the water samples exceeded the limits for different PAHs, the so-called naphthalene, acenaphthylene and fluoranthene, as well as the guide value of the TPH analyte. Some samples exceeded the intervention level established in the NDL for the so-called TPH CoIs: total petroleum hydrocarbons, ethylbenzene y xylenes. Some of the soil samples exceeded the guide levels of toluene, ethylbenzene and xylene analytes. Moreover, they exceeded the limits for different PAHs, the so-called naphthalene, phenanthrene, pyrene, benzo(a)anthracene, dibenzo anthracene and indene (1,2,3-cd) pyrene. Likewise, some samples exceeded the intervention values considered for the so-called TPH and PAH CoI established in the NDL. Based on the obtained analytical results and the selected parameters in the initial characterization, the estimated volume to remediate was of 840m^3, dispersed in an affected area of approximately 4200m^2. As regards water, quantifying its volume was not possible due to its flowing and its fluctuation level.

On the first remediation stage, after signalizing the working area, the heavily contaminated soils were removed for their transport to the oil company's construction site shed for transitory storing, before being sent to final disposal. Some of the soils transported to the construction site shed (the least polluted), with a volume of approximately 70m^3, were stored for further *in situ* treatment. Simultaneously, wells and ditches were built on the affected area in order to recover supernatant via a pneumatic pump, which was stocked in a container and left for decantation to separate water from fuel. The recovered water was oxidized with low doses of hydrogen peroxide to be reused in the soil washing. A total of 313.41 Tn of contaminated soil, 0.38 Tn of absorbent cloth and 2.36 Tn of NAPL were removed and put in containers. The soil washing was carried out using the recovered and hydrogen peroxide-treated water, which was spilled again upstream in the previously built wells and ditches. With this procedure, the treated water is drained again up to the downstream ditch, washing and oxygenating the contaminated soils and displacing the retained hydrocarbons in the interstices of rocks and sands, and it is recovered in the ditches to restart the washing process. The soils from the bases of the digging areas, from which the soils were removed for *ex situ* treatment, were stabilized with industrial-quality anhydrous calcium oxide together with the *in situ*-treated soils, leveling their pH with peat. Finally, low doses of hydrogen peroxide were added in order to oxygenate the soil. Then, the soils stored in the construction site shed were treated via stabilization with calcium oxide and irrigation with hydrogen peroxide. At last, the diggings were covered with replacement soil and the working area was compacted and leveled.

As we can see, the chemical oxidation methodology, also called reduction-oxidation or redox reaction, was used in this first stage of remediation. The method basically consists in a chemical reaction in which one or more electrons are transferred between the reagents, causing a change in their oxidation states. The results of this first remediation stage were successful. Regarding the exceeded values in water samples, oxidation tasks using low doses of hydrogen peroxide were made after the sampling.

On the second stage of the remediation tasks, in March 2015, soil treatment by means of *in situ* chemical oxidation continued on the opposite side of the impact zone, on the landfill area where the hydrocarbon was being kept as a result of soil washing. For that purpose, the contaminated soils were moved to the roadside via road machinery for their stabilization with industrial-quality anhydrous calcium oxide; then, the pH was leveled using peat. Once they were relocated in their place of origin again, hydrogen peroxide in low concentration was injected to oxygenate the soils. Two months later, final remediation tasks were resumed and the impact zone's roadside soils were treated *in situ*. These soils were gathered on a side by means of road machinery and stabilized with calcium oxide. As they were relocated in their place of origin, an oxidation with hydrogen peroxide in low concentrations was carried out. Lastly, about 300 lineal m parallel to the road were treated. For that purpose, the working area was signalized and the soils were removed using road machinery and stocked on a side as the waterway was opened, and stabilized with calcium oxide. They were later relocated in their place of origin and hydrogen peroxide was injected in low concentrations. Finally, the soils were replaced and transferred by a dump truck and scattered on the treatment area using road machinery, together with the previously treated soils in the construction site shed. The area was compacted and the whole working area was leveled.

In December 2015, complementary remediation tasks were carried out in the areas with contamination remnants in the superficial water. Those tasks consisted in irrigations with hydrogen peroxide in low concentrations. After that, a new monitoring focused on those areas was developed in order to verify the effectiveness of the tasks. Then, superficial water sampling and final samplings were performed.

According to the results obtained in the verification monitoring, no superficial water sampling exceeded the guide level established by current regulations (Decree 831/93, regulatory of National Law 24,051; NDL intervention values). Therefore, the site was declared as a place where it was not "necessary to conduct further remediation and/or recovery tasks" in superficial water and soil.

The effectiveness of the used remediation methodology, chemical oxidation, was demonstrated, and in this way we avoided the contamination of a protected ecological reserve as well as the contamination of Yacuy creek and Iguazú river, which flows into Paraná river.

Soil and groundwater remediation in site contaminated with agrochemicals (Villa Ocampo, Argentina)

The contaminated site was located in an urbanized area, with a middle population density next to National Route 11. The property belonged to Unión Agrícola de Avellaneda Cooperativa Limitada (Agricultural Union of Avellaneda, Limited Cooperative Association), branch Villa Ocampo, National Route 11, km 873, in the province of Santa Fe (Argentina). The soil profile featured a brown-colored sandy-clay material over a sandy-muddy material whose color varied from brown-gray to gray.

In January 2014, 12 explorations of contaminated soil were performed, considering a maximum depth of 6 m. In each one of them, samples of soil were extracted at 1 m, 3 m and 6 m (up to slightly above the phreatic level). In four of them, piezometers corresponding to the four cardinal directions were built. The perforations were made up to 2m below the static level of the phreatic layer.

Pictures 7 and 8. Invasive soil and water table sampling tasks in a property contaminated with agrochemicals (Villa Ocampo, Argentina)

Reinforced PVC piping was used for the slotted part and for the blind part. In the annular space formed by the well wall and the slotted pipe selected gravel was collocated as a kind of packaged filter. 36 soil samples were obtained, stored, sealed in glass jars, and kept refrigerated until they were carried to the laboratory.

In the four piezometers the following tasks were performed:

- well purge

- well cleaning, in order to leave it ready to stabilize later and allow the aquifer restoration
- static phreatic level measuring
- phase detection. Non-Aqueous Phase Liquid (NAPL) was not found.

After these tasks, water samples were taken at a depth of 10 m, and then carried to the laboratory.

The laboratory was properly authorized and worked under strict quality control procedures. For analytical determinations, methods defined by USEPA, ASTM or other internationally accredited regulations were used. The samples were appropriately preserved and identified. A strict protocol was followed to guarantee the samples preservation; the protocol was based on the samples monitoring by using Chains of Custody (CoC), which ensured their inviolability until their arrival at laboratory.

The copper value analyzed in soil taken as blank, outside the Cooperative area, was of 5.3 ppm. This value is within the range of the ones obtained for the wells made inside the Cooperative area. This parameter was analyzed because it was not included in the analyses performed by the Laboratory General Direction (DGL in Spanish).

The analytical results of the samples taken in January showed that:

- soil: in none of the analyzed samples pollution levels above the ones established in Decree 831 of the Law 24,051 and in the NDL were found,
- water: all the analyzed samples met the established guide levels.

Superficial soil samples were not extracted because level pollution in superficial soil was already known thanks to the analyses performed by the DGL six months before, in July 2013. The soil samples taken in that moment showed parameters of interest detected for different pesticides. Eight superficial soil compound samples from 0 to 40 cm (in stirred area) and from 0 to 20 cm were extracted. Furthermore, 3 compound soil samples were taken from 70 cm to 1 m in the area near the affected warehouse. Phreatic water samples were not taken. The analyses showed that:

- soil pollution was located from the surface up to less than a depth of 1 m. At a depth of 1 m there were no significant values of the pesticides that were analyzed and detected as parameters of interest by DGL;
- phreatic water was not polluted by the determined pollutants;
- the compound samples taken by DGL at a depth between 70 cm and 1 m showed detected parameters of interest, but these were not found in the sample taken at 1 m. This can be due to the fact that the pollutants had moved from the superior soil layers or to the probable degradation of one of them by microbial action;
- no significant differences were found in the pollutants detected in the different wells below a depth of 1 m, no matter the wells location.

Based on the sampling performed in July 2013 by DGL and in January 2014 by the author of this chapter, the proposed soil remediation method included soil inside the warehouse and external soil surrounding the warehouse from the gate to the wire fence. The depth of the remediation was of 1 m and the methodology used was *in situ* remediation by chemical oxidation with hydrogen peroxide in alkaline medium. This was due to three facts: the sampling and analyses performed by DGL showed that there were no soil pollutants under a depth of 1 m; in the sampling at a depth of 1 m up to the phreatic layer, analyses performed after the remediation showed that there was no pollution neither in soil nor in water; this methodology was the most inexpensive compared to the other methodologies that could have been used in these conditions and allowed the Cooperative to keep operating during the remediation tasks. As a result, it can be concluded that the remediation was successful.

Soil remediation in a rural zone site contaminated with hydrocarbons (Alejo Ledesma, Argentina)

August 31st, 2003. Route 8, km 428.6, 3 km away from Alejo Ledesma, province of Córdoba. A truck heading for La Carlota overturned in the Alejo Ledesma – Arias road shoulder. A mix of 9,000 liters of refined gasoline and 27,000 liters of diesel oil was spilled.

The area affected by the spilt had maximum 70 m long and 18 m wide. Chemical analyses showed that at a depth of 1 m in the soil in the central area of the hydrocarbon spilt was 60,000 ppm; at a depth of 2 m, 410 ppm and at a depth of 3 m, 107 ppm, which showed an obvious reduction of pollutant amount as the depth increased. Water samples were extracted; the analyses demonstrated the presence of traces.

The affected surface was around 700m^2, with an average depth of 2 m. This indicated that the volume of contaminated soil to remediate was 1500m^3. The affected soil was typical of shoulder areas, with features that make them unable for other uses, due to the fact that their original structure is modified due to the tasks performed to make the route (soil compaction), and therefore they are not suitable for farming.

In the area there were no permanent superficial water streams, only little dispersed minor streams and temporary surface runoffs which drain the water and form pools of different sizes, due to the excessive level of soil saturation and to the fact that the phreatic layer is very near the surface (2.5 m). These factors cause the water runoff in subsoil to be slow and difficult. The area was a rural zone, with no urbanization. The nearest populations were Alejo Ledesma, 3 km away (South West direction) and Arias, 20 km away from the spilt site.

Studies that included drilling and sampling were performed in order to develop a preliminary diagnosis to determine the different concentrations and variations of the pollutant, in horizontal and vertical directions. Samples were taken in different areas of the contaminated site.

A quick and precise localization of potentially contaminated areas allows to make an efficient distribution of the wells, and the subsequent reduction of costs and time. An efficient strategy to investigate contaminated soils is:

1. To locate anomalous electrical areas by means of a quick EMI prospection.
2. To take into account the result of this prospection, to select some representative areas in order to perform geoelectric profiles. To delimit geoelectrical anomalies and to compare them with the results obtained by EMI. To validate and specify these results.
3. To dig few wells in selected areas and measure their contamination levels.
4. To correlate the geophysical and chemical results in order to select the anomalies which are probably due to the pollutant. To perform further chemical analysis if necessary.

Once the contaminated soil volume has been specified by means of this procedure, a suitable remediation methodology can be chosen.

In July 2004, samples were taken from soil wells in order to carry out mechanical essays with test tubes with contaminated material and cement in different proportions. The aim was to determine the ideal percentages as a result of solidification and waterproofing of stabilized soils. In December of the same year, an environmental assessment study was performed with analytical determinations of hydrocarbons in soil and water. Two laboratories conducted the analyses. Test tubes with different options of soil-cement and soil-cement-bentonite mixtures were carried out for the contaminated soil stabilization. These mixtures were tested in the laboratory for different periods of time to simple compression and to hydraulic conductivity.

Samples of the test tubes permeate of hydraulic conductivity were taken in order to determine their leacheate. They were analyzed in laboratory. The remediation tasks were performed in the soil above the phreatic layer, which was at a depth of about 2.5 m. According to previous data, the greatest pollutant concentrations, expressed as TPH, were 1 m below the terrain level and significantly decreased as the depth increased. Below the phreatic level only traces of the pollutant in aqueous phase were found. These results showed that the greatest amount of the gasoline and diesel oil spilled was caught in the soil as an isolated phase above the phreatic level.

After a thorough analysis of the obtained data, it became clear that the best technical and economical methodology for the contaminated site remediation was the *in situ* "Stabilization / Solidification" method. This methodology consists in mixing the soil contaminated with hydrocarbons with cement in order to put the pollutant phase inside a solid matrix, to eliminate any probable liquid excess and to reduce the risk of pollutant leak. In other words: the use of this method in this case had the objective of building a monolithic solid with the pollutant either caught inside or making part of the isolated solid matrix by cement addition. In this way, any probable liquid excess is eliminated and the risk of lixiviation is reduced. This method is used to remediate and transform liquids and semivolatile waste materials in a safer and environmentally friendly way. The transformation of contaminated material into a solid block reduces the surface area (surface area per unit mass), or exposition surface, thus diminishing the interaction with the surrounding area. In this way, the pollutant contact with the environment is avoided, due to the fact that the pollutant is macroencapsulated within the solid block. This methodology was chosen because the amount of contaminated soil was so large that its removal for incineration and its subsequent replacement for new soil would have been extremely expensive.

To sum up, the different stages of the soil treatment were: excavation and extraction of contaminated material, mixture of this material with Portland cement and placing of the mixture in the corresponding area. By this sequence, a very high homogeneity and control of the stabilized material can be achieved. The remediation tasks were performed between August and October 2006. These tasks included: a) the construction of the isolation box, b) the stabilization and solidification of contaminated material, c) the coverage and final isolation of treated material, and d) the design and beginning of a monitoring plan after the remediation.

The basic criteria for stabilization design were: to determine the ideal mixture proportion or design of soil-cement and plastic mixture, to determine the cure time, and to have in mind the possibility of an increase in the solidificated product volume. Cure time is the most important aspect because the resistance criterion is used as a control parameter for solidification, and thus for stabilization of contaminated soil.

Some important aspects during the design of the stabilization process were: to determine the optimal proportion in the soil and Portland cement mixture, to determine the time to fully complete the procedure, and to analyze which would be the volume of the solidified product and the isolation box.

The chosen remediation methodology features additional environmental safety measures, since the insulating barrier serves as protection because of its low permeability, avoiding both water entry and the pollutant's leachate. As stated above, different mixture alternatives of soil-cement plastic and soil-cement-bentonite were analyzed for the construction of the insulating barrier. On the other hand, soil-cement mixtures were tested in the laboratory for the stabilization of the contaminated soil. In both cases, the following criteria were adopted in order to establish the proper dosage to obtain the mixture with the lowest execution cost:

- For the impermeable barrier: resistance to simple compression after 28 days, RCS28 > 2.0 kg/cm2; hydraulic conductivity, k ≈ 5x10-6 cm/s.

- For the stabilization / solidification of the contaminated soil: strength to simple compression after 28 days, RCS28 > 2.0 kg/cm2; hydraulic conductivity, k lower than x10-5 cm/s. Lower hydraulic conductivity values might be required in contaminated areas with concentrations of less than 1000 ppm, since leachate was not found during permeability tests. In areas with concentrations higher than 1000 ppm, mixtures that have k ≈ 1x10-5 cm/s hydraulic conductivity will be used.

Simple compression is used as a parameter of reference and as a quality control of the screen, while hydraulic conductivity is the parameter that ensures the sealing of the wall screen and the stabilized material.

For these mixtures' design and selection, laboratory tests were conducted in order to determine hydraulic conductivity and strength to simple compression of the samples.

For the screen plate (values expressed in weight):

- Soil from the area (silt) with 8% of cement
- Soil from the area (silt) with 12% of cement
- Soil from the area (silt) with 10% of cement and 3.5% of bentonite
- Soil from the area (silt) with 10% of cement and 7% of bentonite

The following tests were conducted in each one of the mixtures:

- Hydraulic conductivity after 7 days of molding
- Hydraulic conductivity after 28 days of molding
- Simple compression after 7 days of molding
- Simple compression after 28 days of molding

For stabilization / solidification (values expressed in weight):

- Contaminated soil with 4% of cement
- Contaminated soil with 7% of cement
- Contaminated soil with 10% of cement
- Contaminated soil with 13% of cement
- Contaminated soil with 16% of cement
- Contaminated soil with 19% of cement

The following tests were conducted in each one of the mixtures:

- Simple compression after 7 days of molding
- Simple compression after 28 days of molding
- Hydraulic conductivity after 28 days of molding

In both cases, the water content needed to create a plastic mixture, similar in consistency to a cementitious mortar's, was determined. High moisture content was chosen to obtain conservative values.

Picture 9. Soil removal tasks to monitor soil contaminated with hydrocarbons in a rural area and then remedied by stabilization methodologies (Alejo Ledesma, Argentina).

After remediation, six inspection wells were dug up to 3 m deep. The phreatic layer and the presence of NAPL were monitored.

Water monitoring was carried out every six months, and no pollution was found after five periods. This demonstrated the effectiveness of the remediation.

Conclusions

The previous pages show how the University of Centro Educativo Latinoamericano (UCEL), dependent on Argentina Methodist Evangelical Church (IEMA in Spanish), has worked and keeps working responsibly and with a remarkable commitment to achieve the United Nations' Sustainable Development Goals (SDGs) in general and the SDG 12 in particular, subject of this chapter.

In addition to proposing new forms of development for Latin America by means of a solid academic management in teaching, research and extension, UCEL works incessantly to generate efficient processes in order to obtain new foods and to contribute to the objective of covering the food needs of Rosario and its surroundings, by protecting the environment, using regional raw materials, reducing the amount of waste, increasing EE at a low cost. Among the professional training of ITA students, UCEL incorporates the concepts of CP and EE, reuse and recycle of waste, environmental care, awareness of the current development models and social inequity in food access, food sovereignty and safety for all people, especially the most vulnerable, and change in consumption habits.

In order to achieve SDG 12 regarding production in general and food production in particular, productive industries must definitely adopt CP as a method. To reduce fossil fuel consumption, substantial improvement of EE is also needed, in order to avoid GHG emissions and reduce energy consumption. In regard to people's change in consumption habits, the relevance of reduction or elimination of the consumption of unnecessary or superfluous products and the consumption of products that can be sustainably obtained and satisfy real needs for survival have already been mentioned. Finally, protection of the environmental services that our ecosystem provide us is of extreme importance to avoid pollution and, if pollution occurs, to carry out remediation actions.

In these matters, UCEL continually works to achieve effective compliance of SDGs in order to protect and save our ecosystem. Particularly regarding SDG 12, as this chapter shows, this can be seen in the University's academic offer, in research projects developed in the Pilot Plant and in its headquarters and in the specific remediation tasks performed in contaminated sites.

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