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Exploring the technological demand for effluent management solutions in primary production and processing of agri-food products in Argentina

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Exploring the technological demand for effluent management systems in primary production and processing of agri-food products in Argentina

1. Introduction

This study starts by exploring the generation of effluents in selected segments within the primary production and processing of agri-food products in Argentina. The segments were selected according to the needs expressed by the Embassy of the Kingdom of the Netherlands in Argentina, so that the focus will be placed on beef production and processing, dairy production and processing, poultry production, pork production, vegetable oil production and beer production.

The demand for effluents treatment is based on two assessment levels. The first assessment level deals with the types of residues generated by each production and their environmental impacts.

In order to achieve the first assessment level, we employ both primary and secondary sources. The primary sources include interviews with farmers, managers, waste management specialists and effluent reports from various establishments across the areas of interest. The secondary sources include papers and other forms of research conducted on the types of waste generated by the segments of interest.

After the initial assessment on the types and qualities of the effluents, a description of the mitigation strategies that are currently available in Argentina is put forward. This description includes the companies that are currently providing effluent management solutions in the country.

As summary, a segment with the general conclusions and the potential opportunities for Dutch companies to supply effluent management solutions to this market rounds up the present document.

Finally, this report is of great value for the subject in Argentina since it is the only one currently developed in a comparative way between different sources. It is unique and unpublished and will serve for decision-making both at the regional and local levels.

2. Demand for effluent management in the primary production sector

This section will deal with waste at the primary production or farm level. The residues considered here are a direct result of the activity in question and can be considered as by-products of it. These materials can be classified as dry or wet materials, for all intents and purposes in this study we will be dealing exclusively with wet waste from the selected sectors: beef and dairy, poultry and pork production.

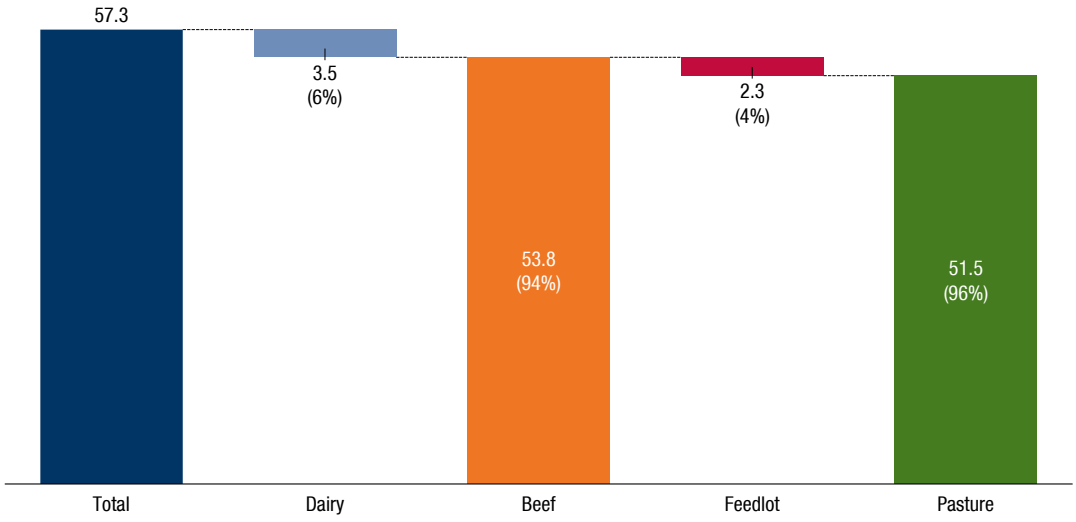
a. Beef and dairy production

i. Introduction

Argentina has an extensive tradition in cattle rearing, dating from the first Spanish settlements in the 16th century. The current stock adds up to 53 million heads of cattle, out of which about 3.5 million heads are dairy cows and the rest are cattle destined to beef production. Out of the over 50 million heads of cattle that populate the beef sector, about 2 million animals are fattened in feedlots every year. Graph 1 shows this data for 2020 from SENASA (National Agri-food Health and Quality Service).

Graph 1. Existences in Argentina by type of production

March 2020, Million heads of cattle.



* Pastureland cattle is mainly raised on grass and may or may have grain supplementation.

Source: Marcos Daziano (2020) based on SENASA.

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The target of this research will include those heads of cattle in dairy farms along with those fattened in feedlots, adding up to just over 5.8 million.

ii. Effluent assessment on feedlots

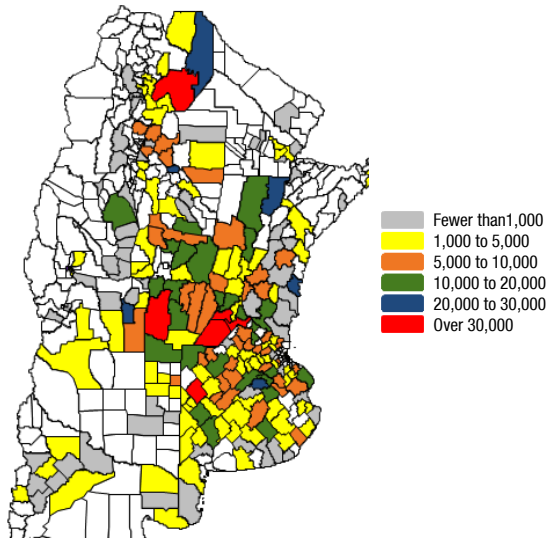
In terms of beef production, this study will cover intensive, confined production (feedlots), as they are the only beef producers that are bound to have effluent issues and therefore, demand technology.

In Argentina, there is no national (federal) legislation regulating feedlots, but rather, provincial regulations cover that vacuum. These differ from province to province and many of the feedlots were established before some of these regulations were in place. The lack of federal regulation

is a key weakness in the system as map 1 shows that even though most of the production happens in the central part of the country, there are feedlots all over Argentina.

Map 1. Heads of cattle in feed-lots by department

2020, Heads of cattle.



- **Feed-lots** are located more **unevenly** than pasture-based production
- There are **pockets of high density**, mostly associated to large **urban areas** and/or readily available **feed supply** (notably corn and soybean meal)

Source: Marcos Daziano (2020) based on SENASA.

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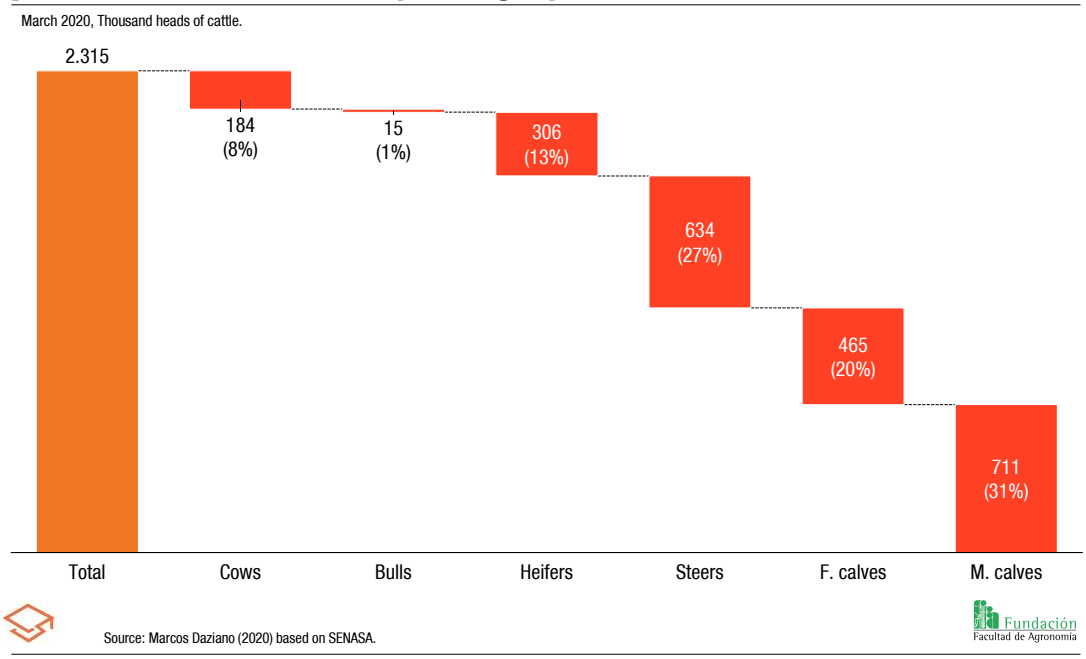
The main environmental and social issues that emanate from confined beef production are related to the management of the cattle's dejections, with water eutrophication, the release of gases and foul smells being the most important. These are often points of conflict when these establishments are located near populated areas.

Cattle dejections vary according to species, age, weight, climate and other factors, but in general terms, it can be estimated at 5 to 6% of the animal's live weight. In Argentina, where British races are more prevalent in beef production and animals are slaughtered at a younger age values tend to be a bit lower than in other countries.

Also worth noting is the fact that depending on strategy and target markets, the categories that go into feedlots vary, some bring in heifers and steers, while others bring in cows to pack on some fat before slaughter. This, of course, affects the duration of the stay for the animal involved. The following graphs show the distribution of animals fattened in feedlots and the average amount of manure produced by an individual of each category per day for the typical categories present in argentine beef production.

Graph 2. Distribution of the heads of cattle destined to beef production in feedlots by category



Source: Marcos Daziano (2020) based on SENASA.

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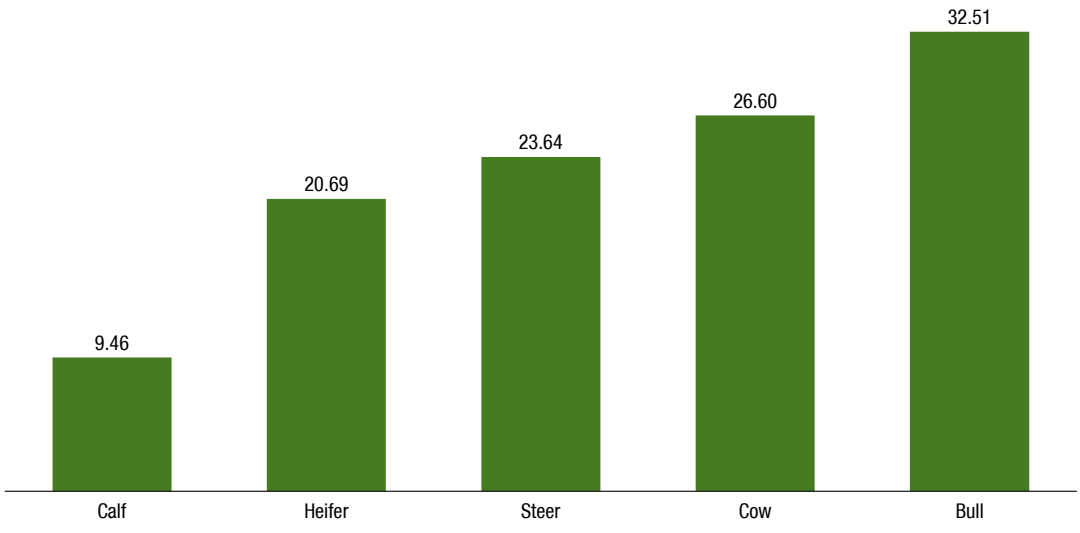
Graph 3. Daily average amount of manure produced by category



Source: Marcos Daziano (2020) based on USDA Natural Resources Conservation Service. Agricultural Waste Management Handbook (1992)

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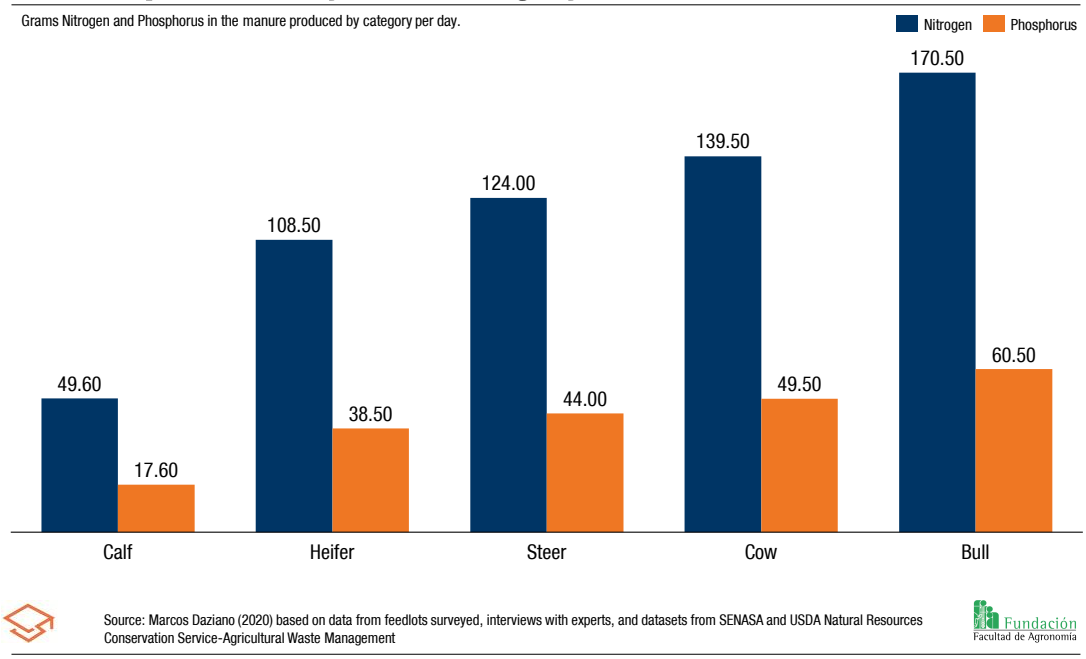
Regarding the composition of the solid manure, it can be estimated that about 80 to 85% of the manure produced is water, while the dry matter composition, which makes up the rest, contains about 3 to 4% nitrogen, 1 to 2% phosphorus, 1.5 to 3% potassium and less than 1% calcium. About 75% of the total nitrogen consumed by the animal ends up being eliminated as bacterial and feed protein (droppings) and as urea (urine). When it comes to the phosphorus consumed this figure adds up to 90%.

Graph 4. Average content of Nitrogen and Phosphorus in the manure produced by each category



Nitrogen has different forms, but total nitrogen, ammonium nitrogen, organic nitrogen, nitrite and nitrate are concerns in runoff. Similarly, phosphorus in runoff may be present as dissolved reactive phosphorus or orthophosphate and may cause eutrophication or other water quality problems. The eutrophication caused by excessive amounts of phosphorus and nitrogen in a water body, is the key reason why liquid and solid manure must be properly disposed of. Dumping them into waterways, as has often been the case, accentuates this over-accumulation and the consequent chemical imbalances but even if not dumped into waterways directly, runoffs and lagoon overflows may occur which end up causing similar effects on surface water and ground water.

iii. Effluent assessment on dairy farms

Current raw milk production stands at close to 11 billion litres per year, strongly recovering after a century low mark of 10 billion litres in 2017. An all-time record production was achieved in 2015 when the country produced over 12 billion litres.

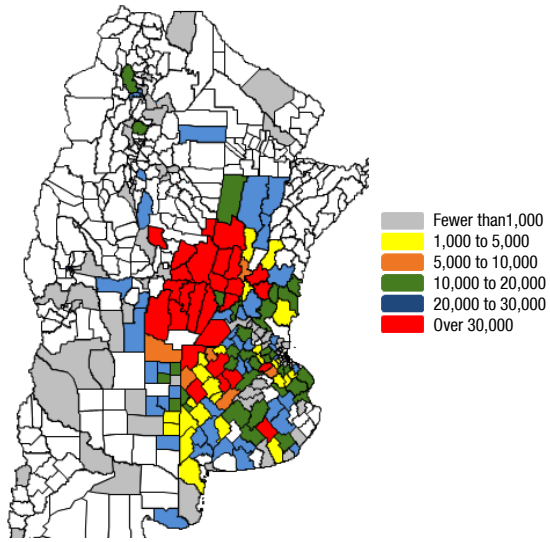
The sector has had its ups and downs and decreasing margins have created a tendency towards fewer, larger dairy farms.

Geographically, dairy farms are more prevalent in higher fertility areas with high concentrations in the central part of Santa Fe, the central and southern parts of Córdoba and the north-western part of Buenos Aires (Map 2).

As previously stated, dairy farms in Argentina add up to about 11,500 and currently hold close to 3.5 million heads of cattle., out of which over half are cows, and female categories in total make up 87% of the stock. Graph 5 shows this category breakdown.

Map 2. Heads of cattle in dairy farms by department

2020, Heads of cattle.



- **Dairy farms** are more **geographically concentrated** than beef production
- The **TOP3 provinces**, Santa Fe, Còrdoba and Buenos Aires add up to **91% of the total stock**

Source: Marcos Daziano (2020) based on SENASA.

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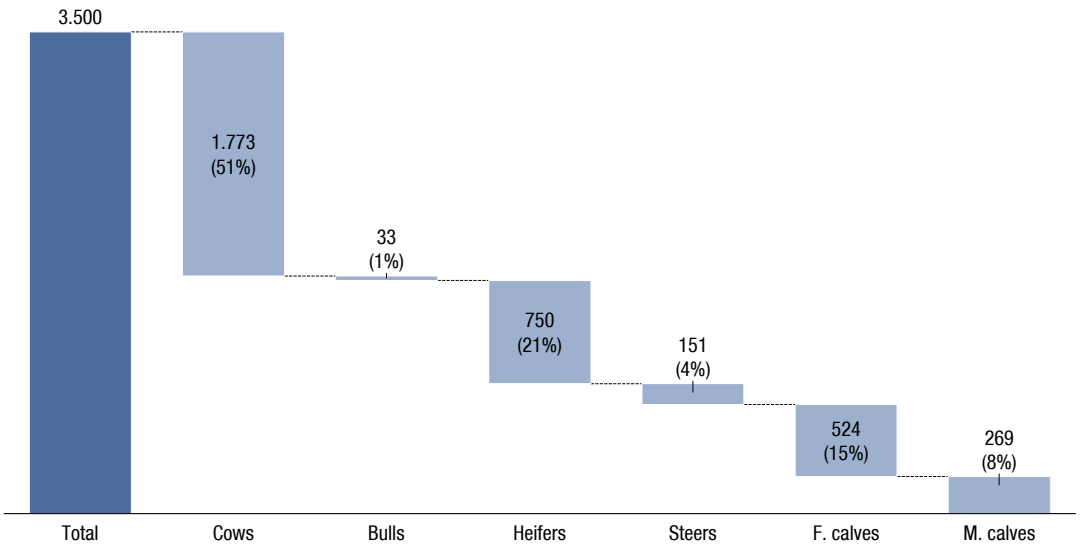
Graph 5. Distribution of the heads of cattle destined on dairy farms by category

March 2020, Thousand heads of cattle.



Source: Marcos Daziano (2020) based on SENASA.

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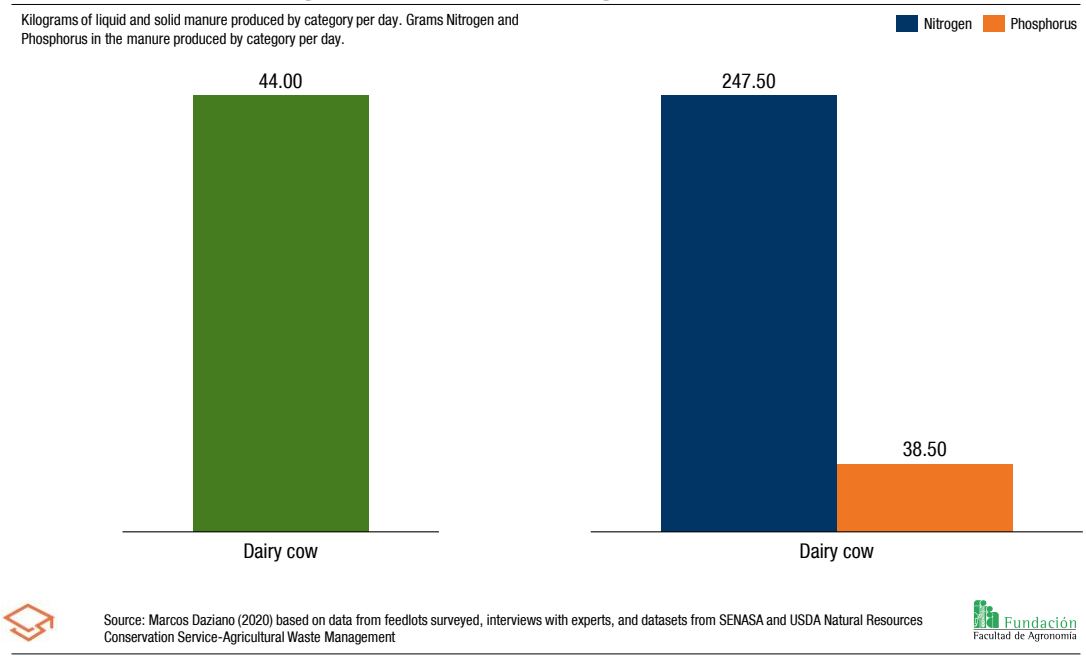
In this section we will be dealing with the effluents generated from dairy farming, while dairy processing will be tackled further on in the document. On-farm effluent management has become much more complex lately as the number of farms has diminished, while the average herd size has increased and production has intensified, often adding supplementation in the form of grains or silage to a previously almost entirely pasture-based diet. Farmers thus face having to treat more forms of effluent as either liquids, slurries or solids.

A dairy cow in Argentina averages 44 kilograms a day of liquid and solid dejections with an average content of 247.5 grams of nitrogen and 38.5 grams of phosphorus per day.

Graph 6. Daily average amount of manure produced by a dairy cow and its average content of nitrogen and phosphorus



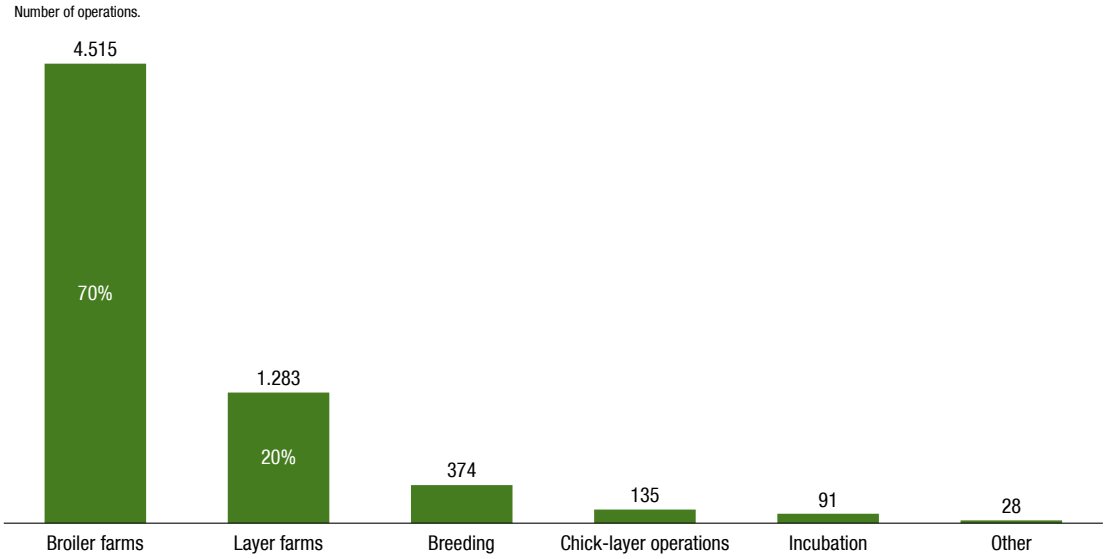
In addition to the cows' dejections the farm dairy (milking and collection facilities) generates the main source of effluent on dairy farms where cows are typically milked for around 270 days per lactation. The effluent generated here is known as farm dairy effluent. In addition to this traditional effluent, more intensive farms generate some other effluents that come from the feeding process, but these will not be addressed in this document.

Dairy farms in Argentina mostly deal with the issue of effluents by dumping them into surface water. It is estimated that 59% of the farmers employ artificial ponds and that about 80% of dairy farms do not have a specifically designed for effluent treatment. Compounding analyses from dairy farms consulted resulted in the following set of values for the effluents generated at the milking, cleaning and on-farm storage processes. The effluent generated had a pH of 7.25, making it slightly alkaline. In terms of the physical and chemical properties of the effluent, the highest concentration found was of potassium at 0.038%, while nitrogen stood at 0.029%. Other notable chemical compounds included phosphorus, sulphur, calcium, magnesium and sodium, all of them at under 0.01%. The content of dry matter stood at 0.355%.

b. Poultry production

Argentina's poultry production has strongly increased over the course of this century, with poultry meat production at over 2 million tons per year and egg production at 829 thousand tons per year in 2018. Basically, two types of animals make up the poultry population in Argentina: broilers for meat production and layers for egg production. There are over 6 thousand poultry operations in Argentina according to official sources, although this figure would be much higher if informal farms were to be added. Broiler farms make up 70% of the total poultry farms in Argentina, while layers add up to 20% (Graph 7).

Graph 7. Poultry operations in Argentina by type



Source: Marcos Daziano (2020) based on SENASA, CAPIA, CEPA.

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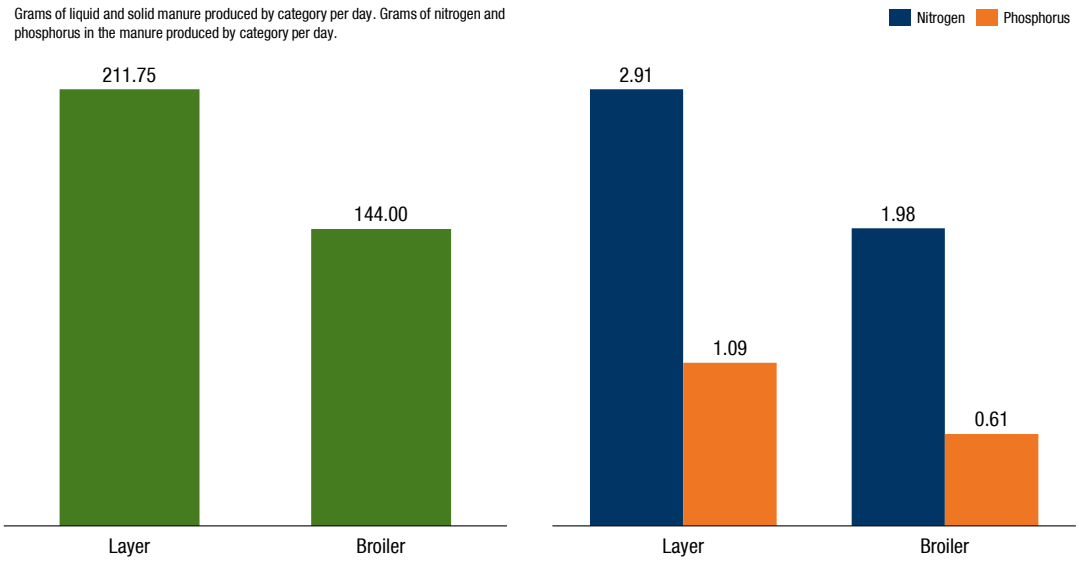
Poultry farms are geographically very concentrated, with Entre Ríos and Buenos Aires making up two thirds of the layer farms and close to 90% of the broiler farms. Poultry farms' waste is made up almost exclusively of solid waste, out of which the vast majority is manure. Graph 8 shows the volume of the dejections and the content of nitrogen and phosphorus it contains for broilers and layers

Graph 8. Daily average amount of manure produced by poultry and its average content of nitrogen and phosphorus



Source: Marcos Daziano (2020) based on data from feedlots surveyed, interviews with experts, and datasets from SENASA and USDA Natural Resources Conservation Service-Agricultural Waste Management

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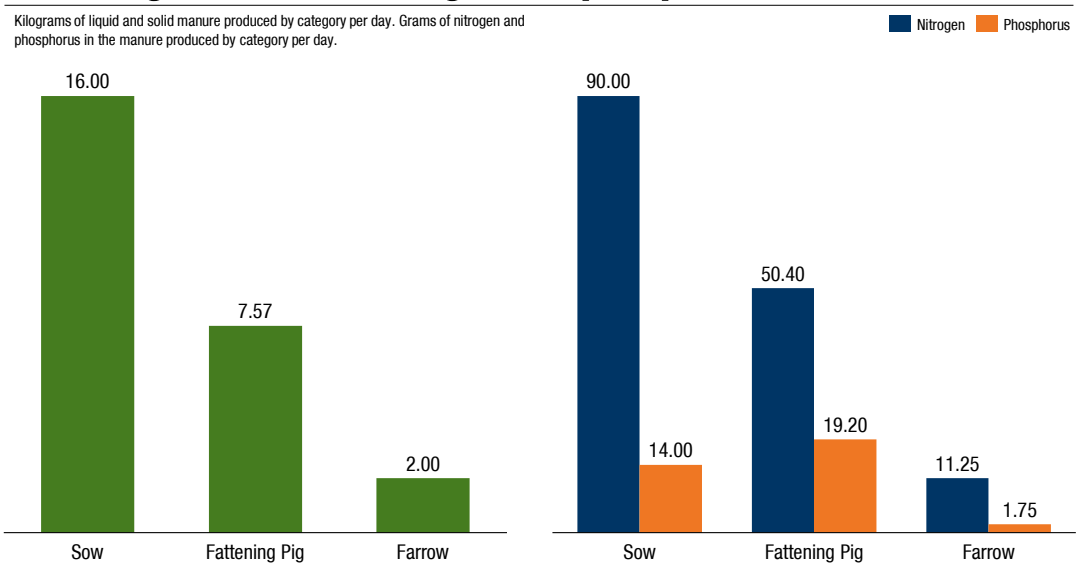
Currently, disposal is mainly in the form of usage of manure for composting and fertilizing, although, there exist some possibilities for effluent treatment in these farms. A very small number of farms have implemented flush systems for waste removal into lagoons for manure and wastewater treatment, mainly those located near populated areas or those that already have a lagoon due to the presence of another activity that requires one. Disposal of poultry lagoon effluent should be an environmental concern for large poultry farm operators. Repeated applications of lagoon effluent can cause high levels of nitrogen, phosphorus, potassium, calcium and magnesium and other elements in the soil and vegetation. The micro-nutrients iron, manganese, zinc, and copper are also present in lagoon effluent. The results from the analysis of two farms that apply this technology show that nitrogen and potassium contents are the highest at 1.02 and 0.89 grams per litre each. Phosphorus, calcium and sodium contents were also relevant at 0.24 to 0.36 grams per litre.

c. Pork production

Argentina produced around 620 thousand tons of pork in 2018. This marks a stark growth over the past decade where production has almost tripled from 220 thousand tons in 2009. The current stock is estimated at 6 million heads. Buenos Aires, Córdoba and Santa Fe make up 70% of the total swine population. These animals are distributed between close to 100 thousand operations of varying degrees of formality. For the purpose of this study, only large farmers with over 500 sows will be accounted for as they are the ones that integrate the process from sow to hog and their scale requires them to engage in some sort of effluent management (however rudimentary). This typology of farmer adds up to just under 90 operations in the whole country.

Graph 9 shows the average manure production and nitrogen and phosphorus contents for sows, farrows and hogs.

Graph 9. Daily average amount of manure produced by pigs and its average content of nitrogen and phosphorus



Pig dejections are about 60% solid and 40% wet on average. Swine manure contains nitrogen (0.08%), phosphorous (0.03%), potassium (0.1%) and many other components. The current

widespread strategy for the farmers that built lagoons for effluent management is the use of this manure as a fertilizer for crops or trees. A small number have gone into biogas production, but overall the vast majority do the minimum required in terms of effluent management. Some larger farmers that use total confinement have implemented the use of decantation systems of multiple lagoons that allow not only the production of biogas, but also the separation of solid and liquid matter for different end uses.

3. Demand for effluent management in the industrial sector

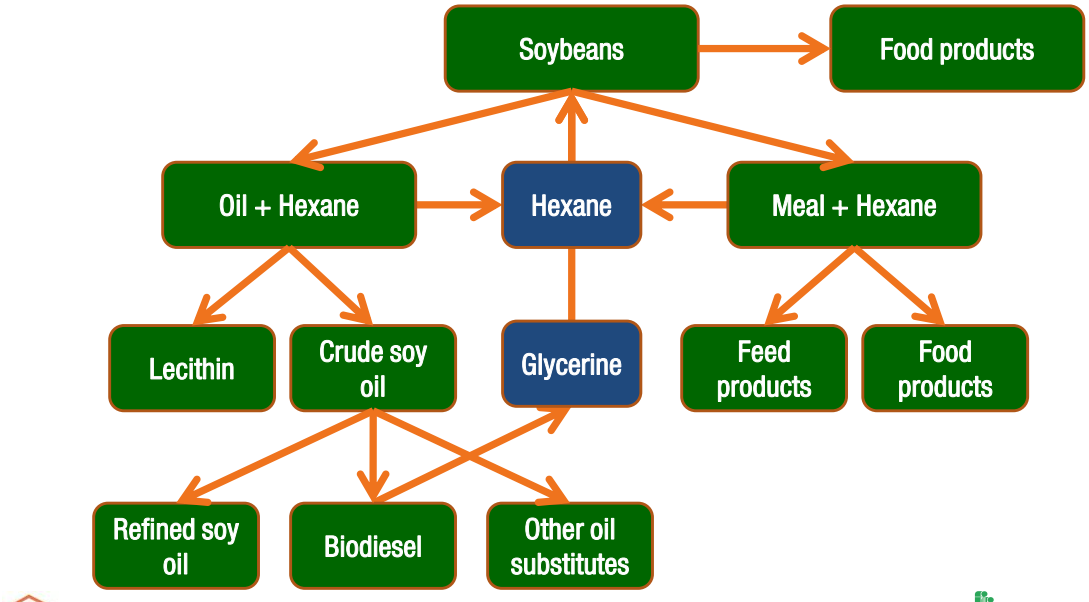
This section will deal with waste at the industrial level. The effluents considered here are a direct result of the activity and include a vast array of products such as heavy water from industrial processes, solvents and fatty acids from soy crushing or blood from slaughtered animals. We will consider the wet and solid materials that end up as residual effluents of the four selected sectors: soybean crushing, abattoirs, milk processing and brewing and malting.

a. Soybean crushing

Argentina's soybean production is estimated at close to 50 million tons for the 2019/20 harvest, while crushing capacity stands at 213 thousand tons per day or over 70 million tons per year. The current use of this installed capacity is estimated at close to 80%, producing over 10 million tons of soybean crude oil and over 40 million tons of soybean meal each year. Close to 90% of this installed capacity utilizes solvent (hexane) extraction technologies, and this is the technology that will be described in this section. In geographical terms, the up-river crushing complex on the Paraná river near the city of Rosario hosts over 90% of the total crushing installed capacity.

Additionally, Argentina has an installed capacity of 4.3 million tons a year for producing biodiesel and over 700 thousand tons a year for refining vegetable oils, with countless other associated operations that produce lecithin, glycerol, food and feed products. Graph 10 shows the process by which these products are achieved, while graphs 11 and 12 show the installed capacity for soybean crushing and biodiesel production respectively.

Graph 10. Description of the transformation process from soybeans to its derivates



Source: Marcos Daziano (2009).

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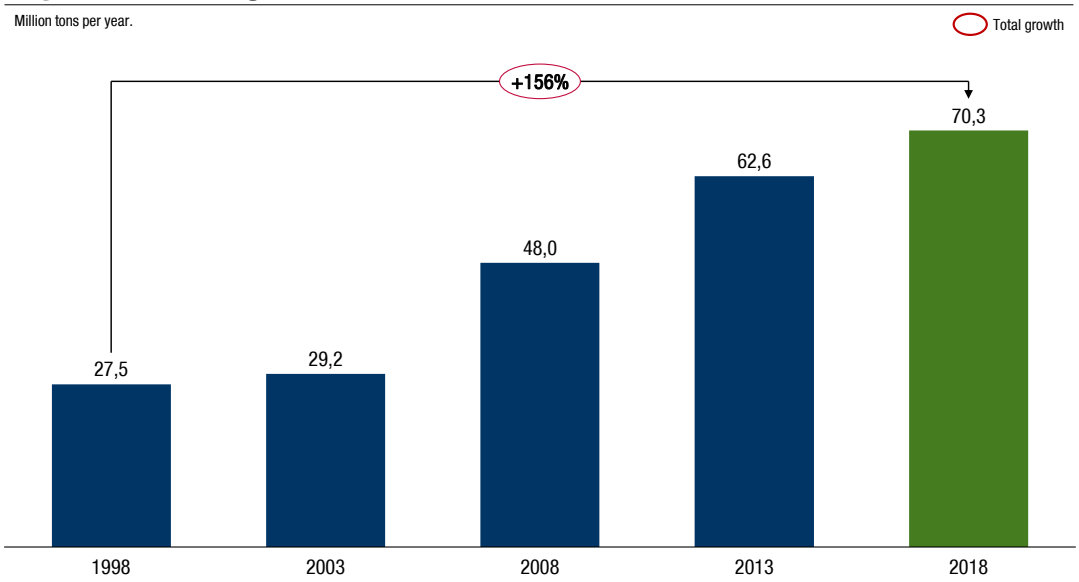
Graph 11. Evolution of the installed capacity for crushing soybeans in Argentina



Source: Marcos Daziano (2019) based on Argentine Oil Industry Chamber (CIARA) and J.J. Hinrichsen Annual report.

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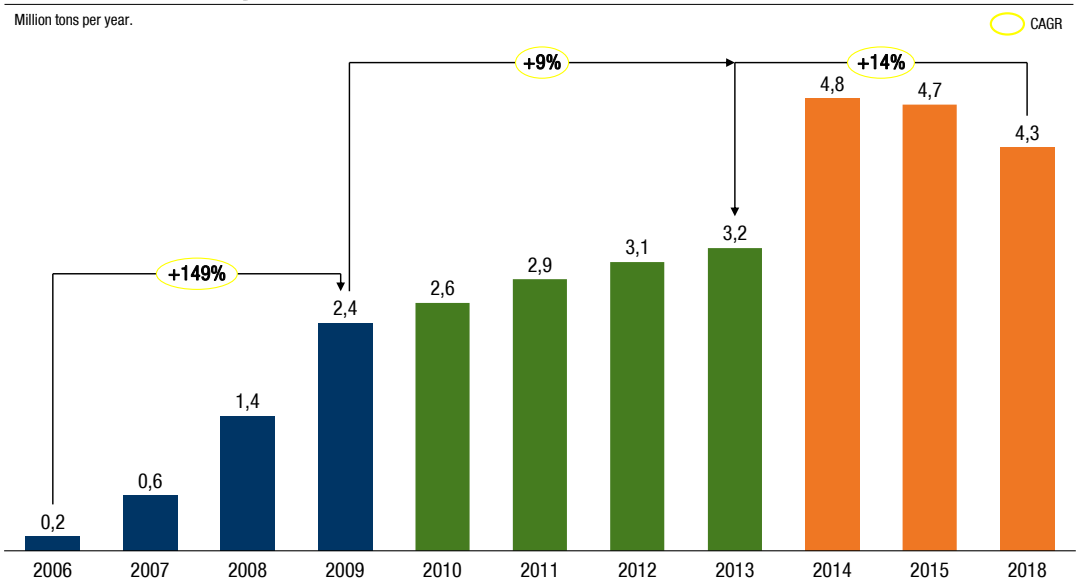
Graph 12. Evolution of the installed capacity for producing biodiesel in Argentina



Source: Marcos Daziano (2019) based on Argentine Oil Industry Chamber (CIARA) and J.J. Hinrichsen Annual report.

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The key issues in terms of effluents in this industry have to do with the soybean cover and the chemicals used during the crushing and transesterification processes. Current effluent treatment solutions in the crushing sector are state-of-the-art as they need to deal with huge volumes with very small areas in which to do so. Formerly, the soybeans were de-hulled, and that hull was tossed away, nowadays it is burnt to generate electricity, such as in in torsional ovens. Meanwhile, the hexane used to extract the oil from the soybean, which was the most difficult problem to tackle, is no longer an issue. Nowadays, crushing facilities have close to zero

hexane content in the effluents they emit. Recycling solutions make it so that this chemical is almost entirely recuperated after the extraction process and is then distilled and transported back to the stocking cells where it is stored for reuse. Only a small fraction of it is lost as it volatilizes when venting. The next big issue with crushing effluents is the presence of several different fats that are separated from the soybean oil at the centrifuge. Modern technologies used in the industry have solved this issue by recuperating these fats and incorporating them into the soybean meal in order to elevate their *profat* content. This, in turn, as the meal is cooked to finish it for animal or human consumption, creates a set of gums that are then removed and stored in holding tanks. These gums are rich in some chemical compounds such as palmitic acid and are then sold to users in a solid form.

On the biodiesel side, the biggest issue is dealing with the glycerol resulting from the process of transesterification used to transform the soybean oil and methanol into biodiesel. Disposing of glycerol is a complicated matter because of the carcinogenic gases it emits. In Argentina, the biodiesel industry has dealt with this by refining the glycerol and transforming it into glycerine that can be used for pharmaceutical purposes. Since many of the companies that produce oil are also producing biodiesel, these facilities are often set together and therefore utilize the same effluent treatment solutions.

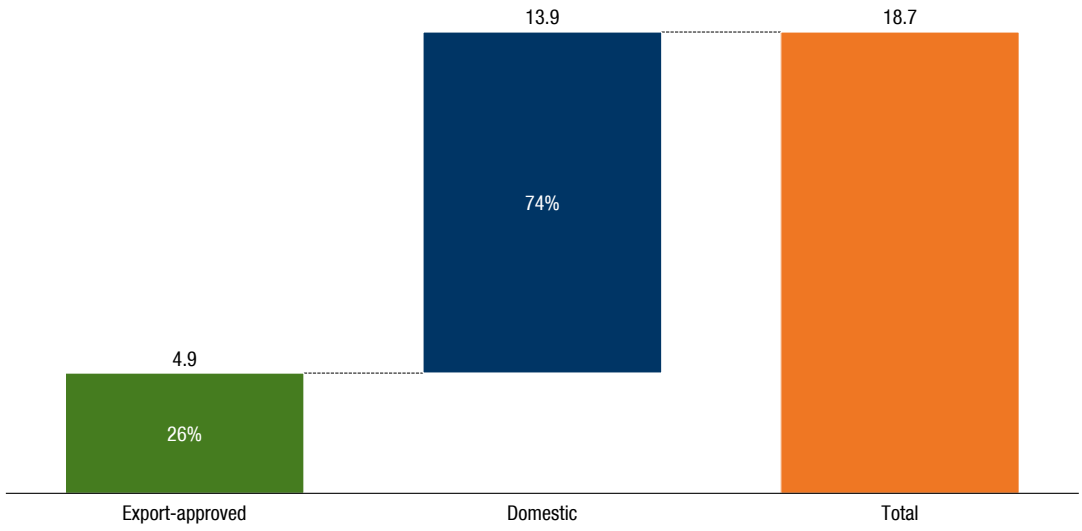
Finally, in the case of refining to produce edible oil, the biggest problem to tackle is the disposal of rare earth elements used as filtering, but effluents are not a difficult environmental challenge.

b. Slaughtering and meatpacking

The meat processing industry in Argentina produces just over 3 million tons of beef yearly, with a slaughtering capacity of close to 19 million heads per year. The industry is clearly domestic-market oriented as just 26% of the installed capacity is export-approved and high informality levels along the supply chain can be verified (Graph 13). This means that there are over 300 slaughtering facilities located in the country that do not meet export standards.

Graph 13. Slaughtering capacity in Argentina by exporting capability

Million heads of cattle. 2018.



Source: Marcos Daziano (2019) based on SENASA.

Since Argentina has not yet attained a free from FMD status, its exports are somewhat limited. Despite this, the country currently exports over half a million tons of beef per year.

This chasm between the domestic and export markets is visible not only in the contractual arrangements between farmer and processing and between processing and commercial links, but also in the type of animal sought after to be slaughtered, the attitude towards innovation and, of course, the technology utilized and willingness to improve it.

The meat processing industry is one of the largest consumers of total freshwater in the agricultural and livestock industry worldwide. Meat processing plants produce large amounts of effluents because of the slaughtering process and cleaning of facilities. These need significant treatment for a sustainable and safe discharge to the environment due to the high content of organics and nutrients. Although physical, chemical, and biological treatment can be used for degradation of these effluents, each treatment process has different advantages and drawbacks depending on the characteristics, best available technology and regulations.

The organic matter concentration in abattoir effluents is usually high, and the residues are moderately solubilized, leading to a polluting effect due to the high levels of organics and pathogens present along with detergents used for cleaning purposes. Effluents generated in abattoirs can be classified as: a) Pre-entrance: those coming from holding stalls, ways and washing systems, mainly composed of urine and manure; b) Bloody: all the effluents containing blood from slaughtering; c) Fatty: those containing fats from different parts of the animal's body that are not recovered for further use.

Typical abattoir effluents contain large amounts of biochemical oxygen demand (over 3,000 milligrams per litre), chemical oxygen demand (over 5,000 milligrams per litre), total organic carbon (about 900 milligrams per litre), total nitrogen (over 500 milligrams per litre), total phosphorus (over 50 milligrams per litre), and total suspended solids (over 4,000 milligrams per litre), with an average pH of 6.5.

Anaerobic treatment is the preferred biological treatment because of its effectiveness in treating high-strength wastewater with less complex equipment requirements. Although anaerobic treatment is efficient, anaerobically treated effluents require posttreatment to comply with required discharge limits where the complete stabilization of the organic matter is not possible by anaerobic treatment alone. Anaerobically treated effluents contain solubilized organic matters, which are more suited for treatment using aerobic processes. Therefore, aerobic treatment systems are more frequently used in effluent treatment systems since they operate at higher rates than conventional anaerobic treatment methods. Considering that oxygen requirements and treatment time are directly proportional to an increase in wastewater strength, aerobic treatment is frequently applied as posttreatment of anaerobic effluents as well as for nutrient removal. The use of combined anaerobic and aerobic processes is beneficial for its potential resource recovery and high treatment efficiency.

In other cases, some slaughterhouse effluents contain toxic, bio resistant, recalcitrant, and nonbiodegradable substances. Thus, advanced oxidation processes might be used to improve biodegradability while deactivating pathogenic microorganisms and viruses, left after biological treatment of the wastewater. Consequently, they are an attractive alternative and a complementary treatment method to biological processes for the treatment of slaughterhouse effluents, especially as a posttreatment method. Combined processes incorporate advantages of diverse technologies to achieve high-quality effluents from industrial and high-strength

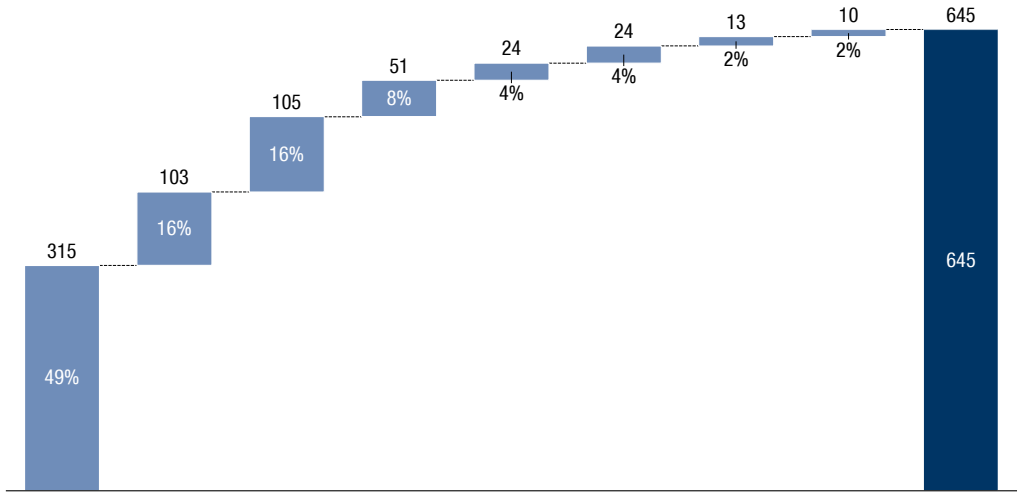
wastewaters for water reuse and resource recovery purposes, although these solutions require heavier investments.

c. Milk processing

The dairy industry in Argentina is composed by around 645 registered milk processing plants, scattered all over the country but highly concentrated in the central region, where most of the milk is produced and where most of the population resides. These plants process roughly 90% of the raw milk produced in the country and vary in size, target markets and end-products. Despite the apparently large number of facilities, the 47 plants that can process over 100 thousand litres add up to 75% of the industry's total output. Graph 14 shows the distribution of these plants according to size.

Graph 14. Dairy processing facilities in Argentina by category

Number of milk processing facilities. Production capacity in litres.



Source: Marcos Daziano (2019) based on OCLA..

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The dairy industry includes the transformation of raw milk into pasteurized milk (which represents 52% of total output), yoghurt (18% of the output), hard, soft and cottage cheese (14% of the output), cream and butter products (3% of the output), ice cream, milk and whey powders, lactose, condensed milk, as well as various types of desserts.

The general distinctions among these foods are due to the reuse of non-fat milk and whey (a by-product in cheese manufacturing) and the evaporation of the free water from the coagulum as well as from milk and whey powders. The effluents originating from various production technologies are not discharged simultaneously, thus forming a stream with wide qualitative and quantitative variations. Notwithstanding the differences in composition, attributable to the manufactured product and technological operations, dairy effluents are distinguished by their relatively increased temperature, high organic content and wide pH range, which requires special purification in order to eliminate or reduce environmental damage. Treatments of dairy effluents include the application of mechanical, physicochemical and biological methods. Mechanical treatment is necessary to equalize volumetric and mass flow changes. It also reduces parts of the suspended solids. Physicochemical processes are effective in the removal of

emulsified compounds, but reagent addition increases water treatment costs. Another disadvantage is the very low elimination of soluble chemical oxygen demand. Therefore, biological wastewater treatment systems are preferred due to the highly biodegradable contaminants.

Generally speaking, the types of effluents can be categorized as: a) Processing waters: formed in the cooling of milk in special coolers and condensers, as well as condensates from the evaporation of milk or whey; and b) Cleaning wastewater: comes from washing equipment which is in direct contact with milk or dairy products. Additionally, the by-products of manufacturing processes, such as whey, milk and whey permeates, can also be grouped separately if they are collected individually from other wastewater streams.

The main pollutant in milk processing effluents is whey due to its high organic and volumetric load. It represents about 85 to 95% of the milk volume and 55% of the milk components. Whey consists of carbohydrates (4 to 5%), mostly lactose. Proteins and lactic acid amount to less than 1%, fats amount to around 0.5%, while salts vary from 1 to 3%. The pH of this wastewater will heavily depend on the products made, as it tends to be more acidic when cheese is made. Typical pH values oscillate between 5 and close to 7. These effluents contain large amounts of biochemical oxygen demand and chemical oxygen demand varying from 0.1 to 100 grams per litre. High contents of nitrogen, phosphorus and calcium are also present in these effluents.

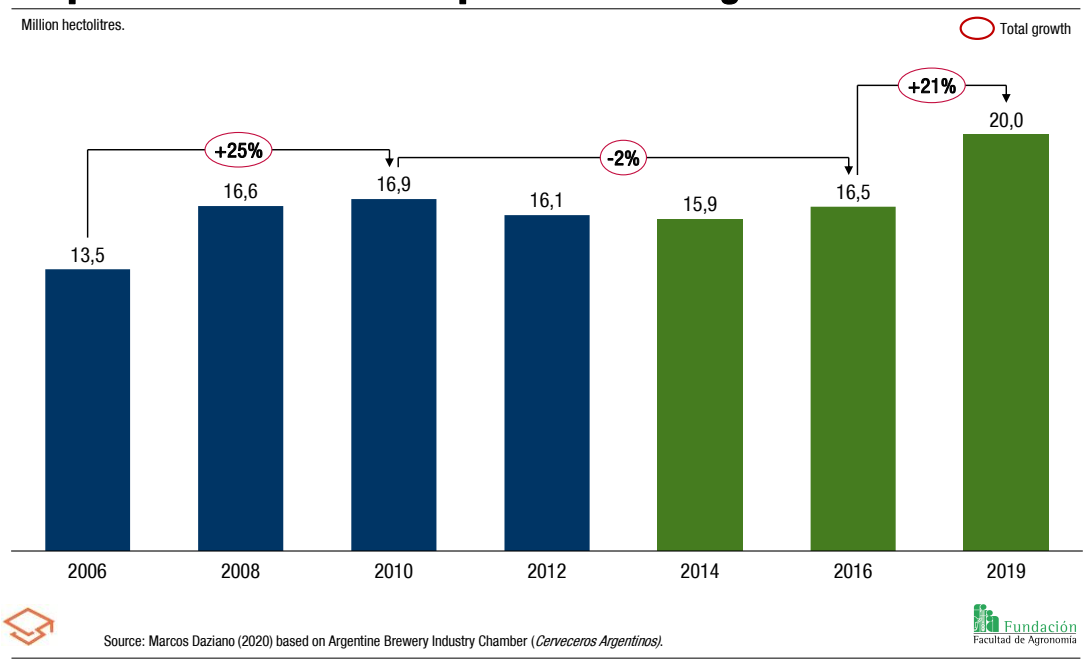
In-plant effluent treatment is the most common strategy for dairy wastewater purification. Typically, it includes mechanical, physicochemical, chemical and biological methods. The mechanical treatment removes suspended solids from wastewater. Conventional mechanical procedures reduce insufficiently the organic load because of the low settleable solid concentration in dairy wastewater. High variations of dairy effluents can cause an instability of the subsequent treatment facilities. Adequate equalization is necessary to smooth the fluctuations in the flow, organic loading, pH and temperature, neutralize residual cleaning agents and destroy excess oxidizers. Physicochemical treatment destroys and reduces milk fat and protein colloids in the dairy wastewater. Chemical treatment removes mostly colloids and soluble contaminants from milk processing effluents. It includes reagent oxidation or pH correction. Finally, biological treatment is one of the most reliable methods for dairy effluent purification, as such methods can assimilate all dairy wastewater components. These processes are very uncommon in Argentina though.

d. Brewing and malting

The brewing and malting industry in Argentina has experienced stark growth over the past decade. Argentina currently produces close to 800 thousand tons of malts and 20 million hectolitres of beer each year. Concordantly, barley production has also increased to 4.5 million tons yearly, harvested on over 1 million hectares. Domestic hops production stands at 300 tons per year, which are complemented with imports amounting to 700 tons, for a total of a thousand tons of hops used by the industry.

Total and per capita beer consumption in Argentina are up over the course of the past two decades and industrial sources forecast continued growth in demand. Graph 15 shows the evolution of beer output in Argentina since 2006.

Graph 15. Evolution of beer production in Argentina



The beer brewing process often generates large amounts of wastewater effluent and solid wastes that must be disposed of or treated. It is estimated that for every litre of beer that is brewed, close to ten litres of water are used, mostly for the brewing, rinsing, and cooling processes. Thereafter, this water must be disposed of or safely treated for reuse, which is a trend on the rise globally and in Argentina.

Brewery wastewater typically has a high chemical oxygen demand from all the organic components (sugars, soluble starch, ethanol, volatile fatty acids, and other compounds). It usually has temperatures ranging from 25 °C to 38 °C, while pH levels can range between 2 and 12 and are influenced by the amount and type of chemicals used in cleaning and sanitizing. These chemicals, which include caustic soda, phosphoric acid and nitric acid ensure that the surfaces are free of any microorganisms harmful to the brewing industry and the public consuming the beer. Nitrogen and phosphorus levels are mainly dependent on the handling of raw material and the amount of yeast present in the effluent. As a result, most large breweries require some degree of wastewater pre-treatment.

The processes by which breweries treat their effluents can encompass one or several of the following types: a) Mechanical methods; b) Chemical methods; and c) Biological methods. Mechanical methods remove coarse solid matter, rather than dissolved pollutants. It may be a passive process, such as sedimentation to allow suspended pollutants to settle out or float to the top naturally. In general, these methods are not sufficiently effective, often resulting in incomplete contaminant removal and separation. Chemical pre-treatment may involve pH adjustment or coagulation and flocculation. The acidity or alkalinity of wastewater affects both wastewater treatment and the environment. Low pH indicates increasing acidity while a high pH indicates increasing alkalinity. The pH of wastewater needs to remain between 6 and 9 to protect organisms. Finally, biological methods are based on the activity of a wide range of microorganisms, converting the biodegradable organic pollutants in the effluents. In fact,

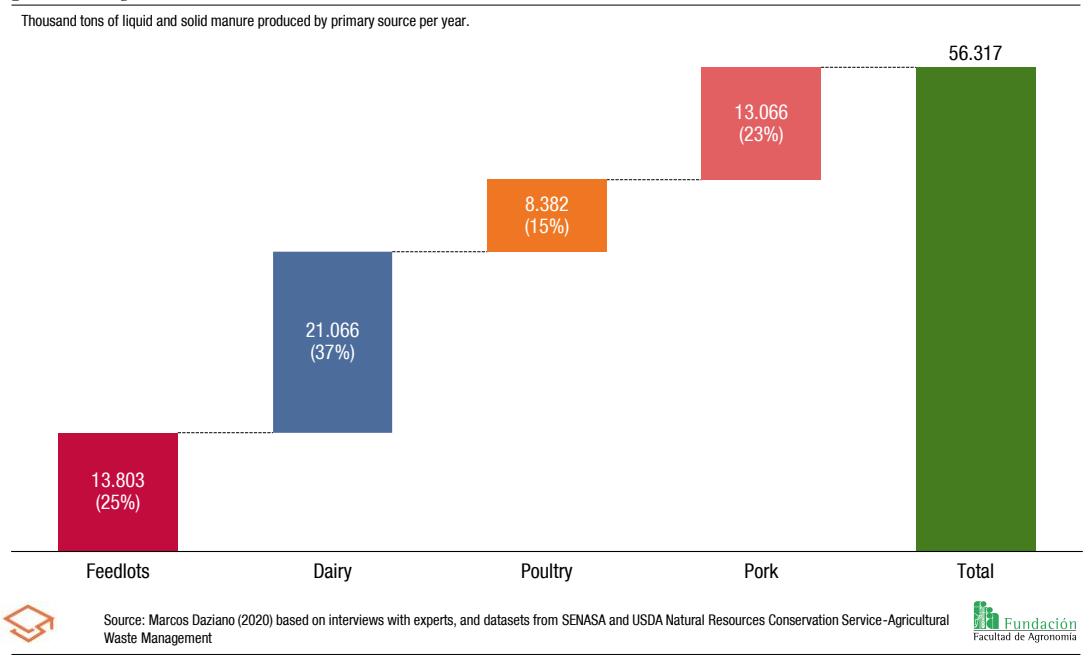
brewery effluents having both chemical (with very high organic content) and microbial contaminants are generally treated by biological methods.

The more modern breweries are treating effluents in a way that they can reutilize the water and attempt to close the loop in terms of water. In this way, the discharged wastewater from the biological pre-treatment processes can be further treated to obtain as a result water that is fit to be reused.

4. Global estimates for effluent generation in selected sectors

When adding all 4 selected primary productions, our model estimates a figure of 56.3 million tons of manure produced in a year, out of which dairy production amounts to 37%, beef production to 25%, pork production to 23% and poultry to 15%. Graph 16 shows this breakdown.

Graph 16. Yearly average amount of manure produced by selected primary sources

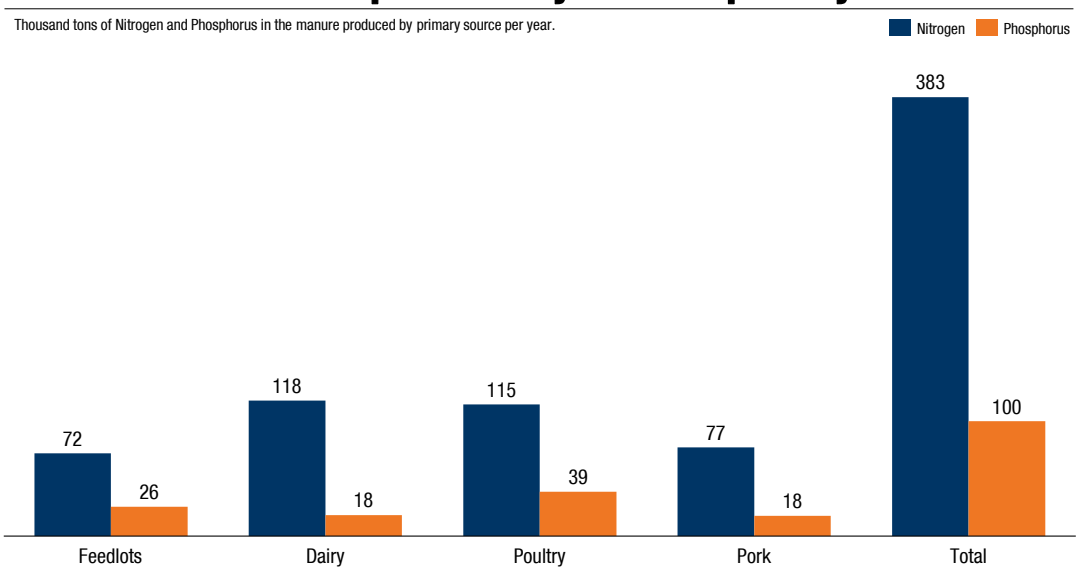


These figures are calculated by taking the stock of interest for each activity and applying the average daily figures shown in section 2. Some notable aspects of the calculation for each sector follow:

1) We have considered a total stock for feedlots of 2.3 million animals per year. To this stock we have applied a rotation factor for each category so that each animal has an average stay length.
2) For dairy production we have only considered dairy cows, 1.8 million heads, and not the other categories. Moreover, we have only taken them into account when they are lactating, which we have estimated at 270 days a year. This is due to the fact that these are the only animals that are confined and where effluents can be gathered.
3) The model uses a population of 44 million laying hens and an instant population of broilers (no overlap) of 94 million. We have assumed that a layer stays on the whole year in the stock, while the broiler is only producing for about 50 days.
4) For pork production we used an estimated stock of 5.6 million heads. Out of this population, we have taken the three most important categories, sows, farrows and fattening pigs, which account for 96% of the total stock and, except for sows, each of the other two animal categories has an average stay length.

In terms of nitrogen and phosphorus content, graph 17 shows that dairy and poultry production are the top nitrogen producers in global figures, while poultry is also the largest phosphorus producer.

Graph 17. Yearly average amount of nitrogen and phosphorus content in the manure produced by selected primary sources



Source: Marcos Daziano (2020) based on interviews with experts, and datasets from SENASA and USDA Natural Resources Conservation Service-Agricultural Waste Management

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As can be observed, the model estimates 383 thousand ton a year content of nitrogen in the manure of these selected activities. At the same time, just over 100 thousand tons of phosphorus are contained each year in the manure produced by the animals in these selected activities.

The figures from the industrial phase will not be covered in this section as they are not easily homogenized. In order to turn out global figures for effluent output, an entire dedicated research would be necessary.

5. Argentine supply

Argentina's current supply of effluent treatment management solutions is provided by a series of local and regional companies. As an annex to this document, a list of 58 companies that are currently competing in the Argentine market can be found. These companies vary from small, local companies to large transnational ones.

These companies undertake several different activities, from chemical and equipment supply to full-on complete solutions supply. Some of these also engage in service supply, such as consulting, waste treatment and disposal.

In terms of the effluent treatment solutions available to this date in the country, they range from very straight-forward, simple, small scale solutions that require about USD 50 thousand in terms of investment to the largest projects announced that easily surpass USD 30 million.

The supply of solutions in Argentina is highly competitive with presence of many of the major competitors worldwide.

To this date, solutions have taken on more of a defensive role, as in addressing environmental issues more than taking effluent treatment as an opportunity for adding new businesses. A large chunk of these investments has been undertaken by local municipalities for the treatment of domestic effluents, taking advantage of loans provided by international development organizations. When it comes to the agro-industrial sector, the biggest investors in these types of solutions have been the crushing sector and the meatpacking sector. The former has tackled the issue of effluent management early on as explained in the section pertaining to the sector, while the latter, has been in the news lately with important investments in effluent management solutions. Gorina and Arre Beef, two of the top 10 beef exporters have announced investments for effluent management to the tune of USD 5 and 1.7 million respectively (interestingly, both hiring Fluence for the job).

An increasingly popular management solution has been that of the incorporation of biogas facilities into effluent treatment. These investments range from around USD 250 thousand to over 1 million.

It is important to state that these investments carry with them an operation and maintenance cost that, for Argentina, can be estimated at around 1 to 1.5% of the final investment, according to the type of technology employed.

6. Conclusions and implications for Dutch companies

One of the key limitations toward the use of more effluent treatment solutions is the fact that in Argentina there is no national (federal) legislation regulating effluent management specifically, but rather broader laws on general water usage. These regulatory faculties are delegated to each province, which must set its own guidelines. This generates inconsistencies and reduces the pull from the regulatory side. Societal pressure, in the form of neighbouring settlements affected by environmental issues or demand from global consumers, has proven to be a much stronger pull for the use of effluent management solutions in Argentina. On the companies' side it is clear from this document that not many react proactively, but rather they wait for the "pressure to act" to do so. It is only a handful of companies that have actively sought to improve their effluent management and it is often related to their sights on export markets, which require such practices.

The problem regarding the treatment of effluents requires a look at regional ecosystems with a strong individual vocation of each producer. The potential to incorporate the treatment of sources into local energy systems, to projects linked to the neutrality of CO2 emissions, management of "recovered" water forces us to think about circular business models with impacts on other businesses, for example horticulture, which maintains a sustainable outlook from the economic, environmental and social aspects.

After constant devaluation processes, growing import restrictions and tariffs, severe lack of financing for production and the current recession fuelled by the COVID-19 pandemic, investment forecasts in Argentina are bleak. Specifically, investment in imported solutions for effluent management in the evaluated sectors will depend on each company's exporting capacities, provided that the quality of the import fills needs that are not met by the domestic/regional market. Exporting companies will be the only ones that will be able to absorb the amortizations in foreign currency of imported equipment, since they receive foreign currency from their exports.

It must also be highlighted that despite its revaluation versus the Euro over the past 5 years, the US Dollar is still somewhat cheaper than the Euro, while Brazilian equipment has significantly improved in quality, all of which could be decisive in the election of the imported machinery's origin if the gaps in quality are not significant. An additional disadvantage for the export of Dutch equipment to Argentina is the 14% duty for the import of capital goods, although there are some exceptions available.

The biggest advantage for Dutch companies is the name brand. Not only are Dutch products for agriculture and food production and the like very well regarded, they are widely recognized as leaders when it comes to water and effluent treatment.

Beyond the institutional limitations, the business models of poultry and pig production, added to the meatpacking industry, should be of high interest for any supplier looking to the argentine market. These sectors show the biggest possibilities in terms of technological and process improvement.

Sources

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CAPIA (Argentine Poultry Industry Chamber). 2019. Statistical reports.

CEPA (Argentine Poultry Processors Industry). 2019. Statistics.

CIARA-CEC Argentine Oil Industry Chamber. 2020. Statistics from its website.

J.J. Hinrichsen. 2019 Annual statistics report.

SENASA (National Agri-food Health and Quality Service) - various datasets on animal production obtained in 2019 and 2020

USDA. 2009. Agricultural Waste Management Field Handbook - USDA Natural Resources Conservation Service-Agricultural Waste Management

Annex - Regional companies that supply effluent management solutions

Company name	Main activities	Location	Country	Telephone	Website
Acquatron	Production and distribution of pumps, control instruments and other accesories worldwide. Their expertise is focused on chemical dosification, pH, RedOx, Conductivity, chloride, chloride dioxide among others. They own their facilities and machinery and have a dedicated staff.	Buenos Aires	Argentina	54 11 49197172	www.acquatron.com.ar
Aeration Servicios S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance; automation; equipment supply; equipment renting and leasing.	Buenos Aires	Argentina	011 5263-9559	www.aeration.com.ar
AGUAMBIENTE La Plata	Technical consulting for effluent management.	Buenos Aires	Argentina	-	www.aguambientelp.com
Aguas y Efluentes S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization; operation and maintenance; effluent transport.	Santiago	Chile	02-2580 1300	www.aguasyefluentes.com.pe/home
Algae Biotecnología	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; Algae biomass production.	SP	Brazil	+55 (19) 3902-4355	www.algae.com.br
ATE Efluentes	Design and execution of effluent management solutions; operation and maintenance; expansion and adequation; chemical supply; training for employees; Consulting.	Buenos Aires	Argentina	-	www.ate-efluentes.com.ar
BioAgroNort	Design and execution of effluent management solutions; third-party reporting; sampling; lab work; Consulting.	Salta	Argentina	(0387) 4228791	www.bioagronort.com
Bioingepro	Sales of equipment for effluent pre-treatment.	Buenos Aires	Argentina	54 11 4890 8643 /44 / 45	bioingepro.com.ar
Biolab Argentina	Biotechnology; Maintenance and treatment of municipal, industrial and agricultural effluent plants; Bioremediation.	Córdoba	Argentina	-	-
BioProSur	Building of custom made solutions; design, production, installation, execution and maintenance.	Buenos Aires	Argentina	(+5411) 5-197-4800	bioprosur.com.ar
BIOQUALITAS	Building of custom made solutions; design, production, installation, execution and maintenance.	Buenos Aires	Argentina	(011) 15 6001-4331	www.bioqualitas.com
Biosano	Sales of products for depuration and treatment of effluents.	Mendoza	Argentina	54 2615560754	www.biosano.com.ar
BRIDGE HYDROGEN S.A	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	Santa Fe	Argentina	3493 426222	www.bhysa.com.ar
Calzetta S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	Mendoza	Argentina	261 4980039 / 261 4985982	www.calzettasa.com.ar
Chaer Ingeniería Ambiental	Technical consulting for effluent management.	Buenos Aires	Argentina	(011) 4521-7986	chaer.com.ar/efluentes-liquidos
Compañía General de Aguas de Córdoba	Technical consulting for effluent management.	Córdoba	Argentina	+54 9 351 663-9356	www.ciadeaguas.com.ar
Coripa S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	Buenos Aires	Argentina, Latin America	(+5411) 4576-3888	www.coripa.com.ar
DAS Environmental Expert GmbH	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	Buenos Aires	Argentina; Peru	54 11 52633641	www.das-ee.com/en
Devre Internacional S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization.	Buenos Aires	Argentina	(54 11) 4732 9203 / (54 11) 4707 0847	www.devre.com.ar
Eco flow	Design and execution of effluent management solutions; expansions; effluent reutilization; specialists on small urban plants.	Santa Fe	Argentina	(0341) 525-3677	www.ecoflowsrl.com.ar
Eco Interbion	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	Buenos Aires	Argentina	+54 011 4776-1113	interbion.com.ar/web
Ecopreneur	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	Buenos Aires	Argentina, Bolivia, Paraguay, Uruguay	4361-8555	www.ecopreneursa.com/efluentes-industriales.php
E-INTRA SRL	Production and distribution of equipment for effluent treatment.	Buenos Aires	Argentina	+54 11 4844-5666 / 1971 / 2197-9624	www.e-intrasrl.com
Erbauen SA	Service supplier for effluent treatment.	Mendoza	Argentina	+54 261 - 4 161 987	erbauensa.com
FAISAN	Production and sales of chemical products for effluent treatment.	Buenos Aires	Argentina	54 11 4275 0679 / 0922	www.faisansa.com.ar
Fluence Argentina	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	Buenos Aires	Argentina	54 2234 64-8888	www.fluencecorp.com
FoxWater	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	SP	Brazil	+55 (19) 3262-0730	www.foxwater.com.br
Geades SRL	Service supplier for effluent treatment.	Buenos Aires	Argentina	(+54) 11 5275 7774	www.geades.com.ar
GreenCo	Service supplier for effluent treatment.	Buenos Aires	Argentina	4776-7627	www.greencoenergy.com.ar
Grupo Falmet	Sales of equipment for effluent treatment and small portable effluent treatment plants.	Buenos Aires	Argentina	54 11 4483 3400	www.grupofalmet.com.ar
Grupo Gancedo	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation.	Buenos Aires	Argentina	+54 0237 463 0460	grupogancedo.com/contacto
Idenor	Sales of equipment for effluent treatment and small portable effluent treatment plants.	Buenos Aires	Argentina	+(5411) 4724-0707	idenoringenieria.com
IMPEC Soluciones Biológicas	Biotechnology; Maintenance and treatment of municipal, industrial and agricultural effluent plants; Bioremediation.	Buenos Aires	Argentina	54-11-47624151	www.impec.com.ar
Ingeniería DZ	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; consulting.	Santa Fe	Argentina	-	www.ingenieriadz.com
INSAAP	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; consulting.	Buenos Aires	Argentina	+54 9 221 489-5680	www.insaap.com.ar
JMG Ingeniería	Technical consulting for effluent management; operation and management.	San Juan	Argentina	-	jmgingenieria.webnode.com

Company name	Main activities	Location	Country	Telephone	Website
MACS SA	Design and execution of effluent management solutions; expansions; effluent reutilization.	Buenos Aires, Río Negro	Argentina	+54 911 66467803 / +540230 4495225 / +54 9291 5041410	www.macs-sa.com
Metac S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization.	Buenos Aires	Argentina	+54 (11) 4716.0203	metacsa.com
MeterMetertech S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization; bioremediation.	Córdoba	Argentina	+54 (0351) 4744328	www.metertech.com.ar
Opeci SRL	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	(+5411) 4005-5176 / 5198	www.opeci.com
Paques	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.		Brazil, Argentina	+55 (19) 3429 0600	www.paques.com.br
Química EG S.R.L.	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Entre Ríos	Argentina	54 11 70790210	www.quimicaeg.com.ar
Reverder	Service supplier for effluent treatment.	Buenos Aires	Argentina	0230-4486119 /4486690 /4487592	www.reverder.com.ar
Reysud	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	+54 (0230) 446 4403	www.reysud.com
Seguridad Biológica	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	-	www.seguridadbiologica.com
Sertec S.R.L.	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	(54-11) 4552-3228	sertecargentina.com.ar
Serviur	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	(+5411)4786-3888	serviur.com
Sigma Cuyo	Service supplier for effluent treatment.	Mendoza	Argentina	0261 431 0187	www.sigmacuyo.com.ar
Spur Ambiental	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	(054 11) 4791-7188/ (054 11) 4791-0260	spurambiental.com.ar
SSR S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	+54 11 4836 2360	www.ssr.com.ar/index.html
Symec	Service supplier for effluent treatment.	Buenos Aires	Argentina		www.symec.com.ar
Taersa SA	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	54 11 4902 0503	www.taersa.com
Teyser Efluentes	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	54 9 11 3629 2997	www.teyserefluentes.com.ar
Tratagua	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Mendoza	Argentina	0261 4307574 /4373200	www.tratagua.com.ar
Turn Green	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	54-11-2298-225	www.turngreen.com.ar
TYBSA	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Santa Fe	Argentina	+54 (0342) 456-0216/455-5744	www.tybsa.com/contacto
Uventech S.A.	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; operation and maintenance.	Buenos Aires	Argentina	+54 11 5350 1902	uventech.com
Veolia	Design and execution of effluent management solutions; expansions; effluent reutilization; renewable energy generation; waste management and destruction.	Buenos Aires	Argentina	+54 (11) 4542 1100	www.veolia.com.ar