Carbon footprint - coal vs. coconut

granular activated carbons for drinking water

Jacobi Activated Carbons solutions, reduce your carbon footprint and optimize the budget of your drinking water plant

All along its continuous evolution throughout the years, Jacobi Carbons has always taken great pride in helping its customers to resolve the challenges they face. Committed to offering you the highest quality products and services in the business, Jacobi incessantly develops successful solutions capable of meeting your needs and the ones of the future generations.

To give you the opportunity to be both an environmentally-friendly and a cost-effective company, Jacobi has taken a pioneering approach and offers you a full range of Sustainable Development solutions, in particular:

- Reactivation of your spent carbon
- Activated carbons made of vegetal, natural and renewable resources

These solutions will help you to:

Produce high quality water

Jacobi provides technical expertise and assistance to **ensure higher treatment efficiency, hydraulic performances and maximum product lifetime** of its products compared to that of other activated carbons on the market.

Regarding reactivation, thanks to the high quality processes and controls that we operate on our sites, the resulting product can often recover almost its entire original adsorption capacity and can therefore be then returned to the process from which it originated, giving high level of performances in the filters. Moreover, Jacobi has an extensive and **successful experience in reactivating spent carbon from drinking water plants** for several years. The Jacobi Carbons Group is **ISO-certified for quality.**

Reduce your costs

Thanks to Jacobi's solutions, carbon footprint reduction requires **no investment** in infrastructure. Activated carbons made of vegetal, natural and renewable resources adapt perfectly to water treatment lines equipped with fossil GAC.

Furthermore, reactivation typically represents **20% savings** compared to replacement by virgin GAC. Indeed, the reactivation process uses existing material and you have therefore only the cost of the processing operation, and transportation to and from the regeneration facility to consider. **This makes it a very cost-effective option,** especially compared to buying virgin activated carbon and paying for the disposal of your spent one.

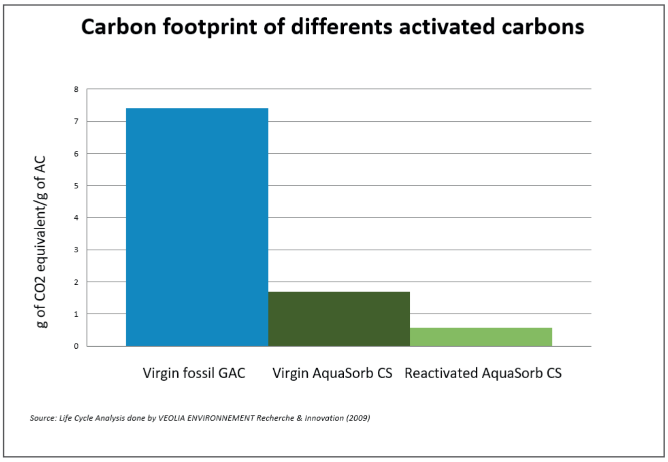
Reduce the carbon footprint of your plant

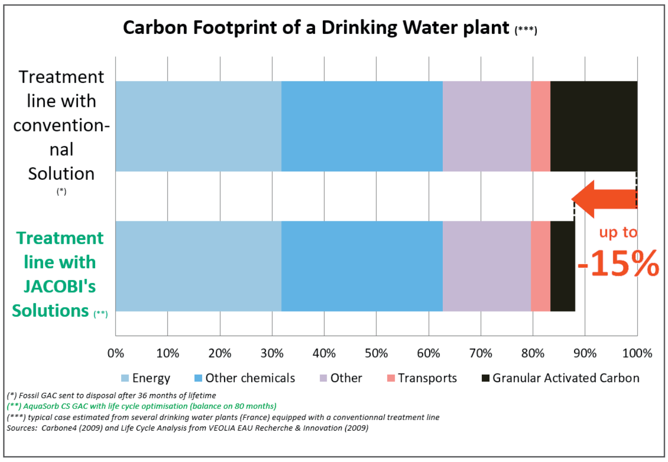
Jacobi's Sustainable solutions can help you to:

- **Immediately reduce 75% of your carbon footprint from Granular Activated Carbons (GAC),** by replacing fossil activated carbons with activated carbons made from vegetal, natural and renewable resources like AquaSorb™ CS

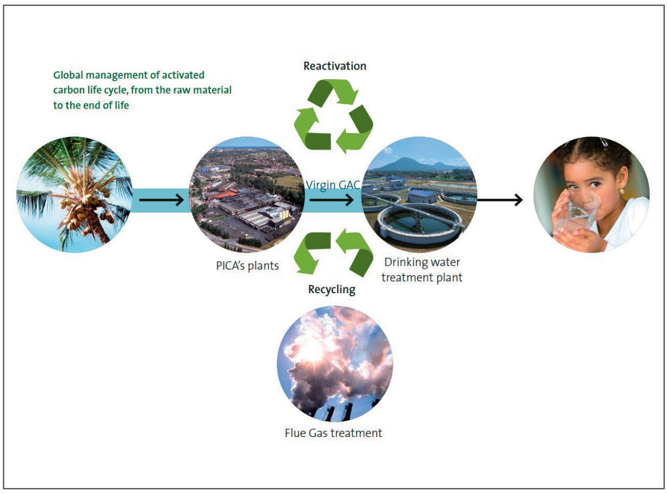
Some literatures state that activated carbon is responsible for around 20-25% of the global carbon footprint of standard drinking water plants.

In this configuration, changing from installation and replacement of coal-based GAC to installation and reactivation of AquaSorb™ CS will help you to reduce **10 to 15% of the global carbon footprint of your drinking water plant**, as illustrated in the graph bellow.





- **Optimize the life cycle of your spent GAC**, by reactivating or recycling rather than disposing.



Such a high reduction is hardly achievable with the other contributors of the global carbon footprint (energy, chemicals...).

For a drinking water plant producing 6 MGD of water (that is to say 1000 m³/h), it prevents the greenhouse gas emissions of:

- a car circumnavigating the globe 20 times a year!
- the electricity consumption of several thousand light bulbs every year!

Moreover, Jacobi also offers you to:

- Reduce the volume of waste production by 75% by giving value to your spent GAC.
- Protect natural fossil resources and reduce consumption with the use of vegetal, renewable raw materials.

And, more generally, contribute to Sustainable Development

Activated carbon has been long-recognized for its characteristic of reducing pollution. Activated carbons are very widely used to purify two essential elements of Life: Water and Air. Jacobi Carbons has been directly involved in the protection of people and their environment.

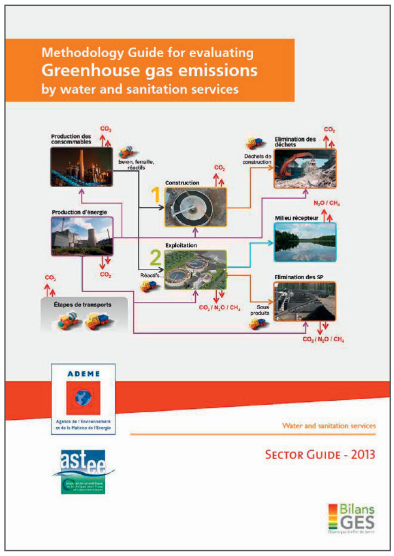
As an originally Swedish company, we take our environmental responsibilities very seriously. This is why, over and above the benefits provided by its Activated Carbons, Jacobi Carbons has been working for several years to continually improve the control and improvement of the environmental, economic and social impacts of its activity and products; with the goal of developing efficient solutions that meet the needs of future generations.

Jacobi Carbons is the first activated carbon manufacturer to take these resolutions, motivated by the desire to contribute to the achievement of ever more ambitious international goals in terms of social responsibility, economic development and environmental protection.

In recent years, Jacobi Carbons has invested substantial capital to become the largest manufacturer of activated carbon made from renewable raw materials, i.e. with the lowest carbon footprint. In addition to meeting strict local environmental standards, the Jacobi Carbons Group is ISO certified for environmental standards. Our activation and reactivation plants are managed according to strict local societal standards. They contribute to local economic and industrial development.

Jacobi Carbons is now focused on raising awareness among its partners and customers about environmental issues and encouraging them to adapt their behavior, in particular by encouraging them to prefer activated carbon with the lowest carbon footprint.

To meet this goal, Jacobi Carbons makes and effort to widely disseminate the information concerning the carbon footprints of activated carbons. It has also contributed in particular to the preparation of the *Methodology sector guide for the evaluation of Greenhouse Gas emissions by water and sanitation services*, done by the Scientific and Technical Association for Water and the Environment (ASTEE). This French scientific and technical association, recognized as being of public utility and empowered to make recommendations to the public authorities, aims to produce and disseminate reference technical information and to conduct in-depth discussions on the methodological, technical and regulatory aspects about drinking and waste water management, rainwater, aquatic environments, waste management and the quality of the environment.



Comparative life cycle analysis of activated carbons made from vegetal natural renewable raw material or fossil resource - case of drinking water treatment -

Why a Life Cycle Analysis on activated carbon?

Activated carbon (AC) is widely used for the production of drinking water. The evaluation of the environmental impacts of the production of drinking water has shown that activated carbon production represents a significant proportion of the total impact of water treatment. Thus, activated carbon is potentially a leverage to reduce the global environmental impact of a drinking water plant. However, these studies used generic emission factors not really representative of the real activated carbon used in water plants.

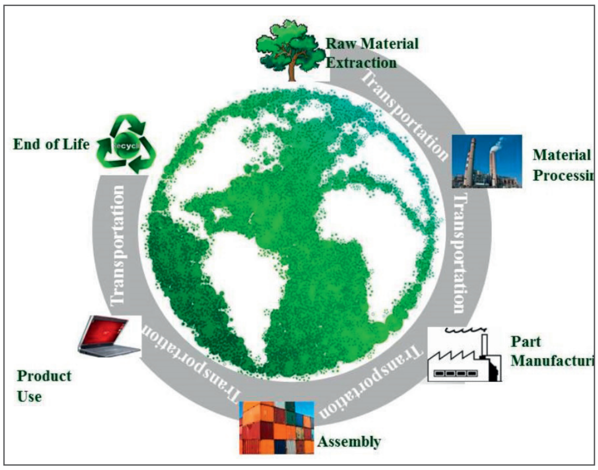
In particular, Jacobi has a wide range of activated carbons: fossil (coal) or vegetable (coconut, wood) raw material, physical or chemical activation, in granular or powder form … Thanks to its technical expertise, Jacobi recommends "the Activated Carbon Solution" best suited to meet the needs of each operator.

To address the lack of data, PICA, a Jacobi Carbons company, has launched a Life Cycle Analysis (LCA) study, conducted in 2009 by Veolia Environnement Recherche & Innovation (VERI), recognized as an expert in LCA studies.

The purpose is to compare the environmental profile of different types of activated carbons used by operators for drinking water treatment and thus improve the accuracy of the environmental impact assessments of the drinking water production lines. This rigorous and detailed study is a First in the "World of Activated Carbon ".

What is a Life Cycle Analysis ?

A life-cycle analysis is a technique to assess environmental impacts associated with all the stages of a product's life from **cradle-to-grave.**



Its goal is to compare the full range of environmental effects assignable to products (or services) in order to improve processes, support policy and provide a reliable basis for informed decisions.

Perimeter of the Life Cycle Analysis of Jacobi's activated carbons

Scope of the LCA

The LCA study done on Jacobi Carbons' activated carbons focuses on products used for drinking water production. The impacts generated by activated carbon are calculated "in m^3 of water produced" rather than "per kg of activated carbon".

Several functionnal units have been studied, depending on the application of activated carbon (organic matter removal and/or pesticides), on the water quality inlet activated carbon (medium or high level of contaminants), and on the water quality expected after activated carbon treatment.

The LCA study deals with the four main activated carbon families in Jacobi's range, as well as with reactivation of spent GAC. Activated carbons are distinguished by the raw material used, and by the type of activation:

- coal-based activated carbon (fossil), steam activated
- coconut-based activated carbon, steam activated
- wood-based activated carbon, steam activated
- wood-based activated carbon, chemically activated

Other parameters distinguish scenarios:

- Form: Granular (GAC) / Powder (PAC)
- Production site: Jacobi Carbons' site in Vierzon (France) or production sites in Asia
- Process: Conventional treatment line / ACTIFLO™CARB process
- Management of the end of life (for GAC only): Recycling as proposed by Jacobi Carbons or disposal.

The combination of the functional units and all the parameters listed above, leads to the definition of 27 scenarios.

For the sake of simplicity, we will only present in this document the results concerning the two products most widely used to treat organic matter and pesticides: **coal-based GAC and AquaSorb™ CS** (coconut-based GAC), in the framework of the most commonly experienced functionnal unit, i.e. "Reduction of **organic matter** concentration from 2.5 mg/L to 2 mg/L, and reduction of **micropollutants concentration** from 0.2 µg/L to 0.1 µg/L Atrazine-equivalent, as a continous treatment, while producing 1 m^3 of drinking water".

The conditions are as follows:

PARAMETER	COAL-BASED GAC	AquaSorb™ CS
Volume of a backwashed bed	1 m^3	1 m^3
Volume of dry GAC to fill the filter	0,84 m^3	0,84 m^3
Apparent density	0,49 g/cm^3	0,50 g/cm^3
Empty Bed Contact Time	12 min	12 min
Flow	5 m^3/h	5 m^3/h
GAC life (between 2 reactivation operations)	20 months	20 months
Number of reactivation	2	3
Quantity of make-up to compensate for reactivation losses	20%	20%

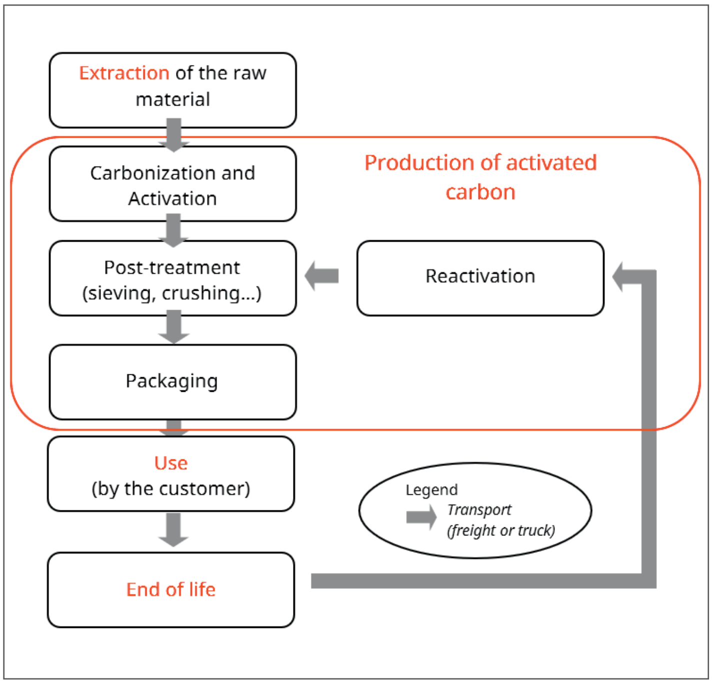
THE DATA NEEDED TO CALCULATE THE REFERENCE FLOW HAVE BEEN PROPOSED BY JACOBI AND VALIDATED BY VERI. IT MAY BE THAT THESE DATA DO NOT ALWAYS CORRESPOND TO REALITY, THE OBJECTIVE BEING TO REPRESENT AN "AVERAGE" CASE.

The reference flows are therefore:

- for the coal-based GAC scenario: 2.62 g of virgin AC / m^3 of treated water + 2.99 g of reactivated AC / m^3 of treated water.
- for the AquaSorb™ CS scenario: 2.29 g of virgin AC / m^3 of treated water + 3.44 g of reactivated AC / m^3 of treated water.

Life cycle of the products

The life cycle considered is as follows:



Choice of the impact categories

The impact assessment method chosen is “Impact 2002+” method, modified in accordance with the IPCC recommendations (period considered for GHG impacts equal to 100 years).

The LCA study done by VERI measures the contribution of activated carbon to various environmental issues, according to the following impact categories:

- Global Warming : Emission of GreenHouse Gas (GHG) : not only CO_2, but also various other gases (methane, nitrogen oxide ...)
- Natural resource depletion
  - Consumption of fossil fuels
  - Extraction of minerals
- Damage to ecosystems
  - Land use
  - Acidification (terrestrial and aquatic)
  - Ecotoxicity (aquatic and terrestrial)
- Damage to human health
  - Respiratory effects
  - Toxic elements (human health cancer, human health noncancer)
  - Photochemical smog
  - Ozone depletion
  - Ionizing radiation

Jacobi Carbons is pleased to share these results, and to demonstrate the benefits of its solutions.

For simplicity, the contribution to global warming, i.e. greenhouse gas emissions (expressed in tons of CO_2 equivalent) is presented in this document, under the name “Carbon Footprint”.

Quality of the data

As a manufacturer of activated carbon of more than 100 years of existence, Jacobi Carbons has a large experience in activated carbon production. This is why the primary data concerning activated carbon production phase comes from Jacobi Carbons. These have been calculated theoretically (mass balance, energy balance, etc.), or are derived from measurements made directly on the Jacobi’s production site in Vierzon (France). These data are recent (2009).

The data used to calculate reference flows for the different types of activated carbon (PAC concentration, lifetime, contact time, number of reactivations, etc.) were also provided by Jacobi Carbons and validated by VERI.

The data relating to the operation of activated carbon in drinking water plants comes from studies carried out on Veolia facilities.

For all other processes (transport, extraction of raw materials ...), the data come from the reference database: Ecoinvent (updated in 2008).

Hypothesis

- *The packaging phase is out of the study boundaries: this step is considered identical for all types of activated carbons.*
- *The necessary infrastructure for the production of activated carbon (manufacturing facilities) is considered identical for all scenarios. Construction and dismantling of plants are not considered in the study.*
- *Only one-way trips are considered during transport phases.*
- *The study takes into account the country in which each step of the life cycle is carried out, in particular for the energy mix.*
- *For the activated carbons produced at Jacobi Carbons' site in Vierzon-France (ISO 14001 certified), the study takes into account the treatment of liquid and gaseous effluents carried out at the plant.*
- *Negative CO_2 consumption during plant growth is not taken into account. CO_2 (and CO) emitted during the combustion of biomass products does not contribute to the greenhouse effect (biogenic CO_2). These assumptions are consistent with IPCC recommendations.*
- *The cultivation of coconut is out of the study boundaries. Indeed, coconut is not grown specifically for the production of activated carbon. The husk is considered as a by-product: the impacts of growing coconut are not attributed to the production of activated carbon.*
- *Regarding the "use" phase of activated carbon, the consumption of electricity necessary to operate AC in a drinking water plant is counted. In particular, a GAC filter requires the pumping of the water necessary to compensate for the pressure drop caused by the filter. The values used are estimates for installations operated by Veolia. It is likely that GAC requires an ozonation step upstream. Due to the lack of information on this subject, the ozonation step was excluded from the study.*
- *The end of life of spent GAC (disposal or recycling) represents an "avoidance" of GHG emissions. However, these "negative" values are not included in the calculations nor considered in the results presented.*

The results presented are specific to Jacobi Carbons products insofar as they take into account their specificities. For any clarification, please contact Jacobi Carbons.

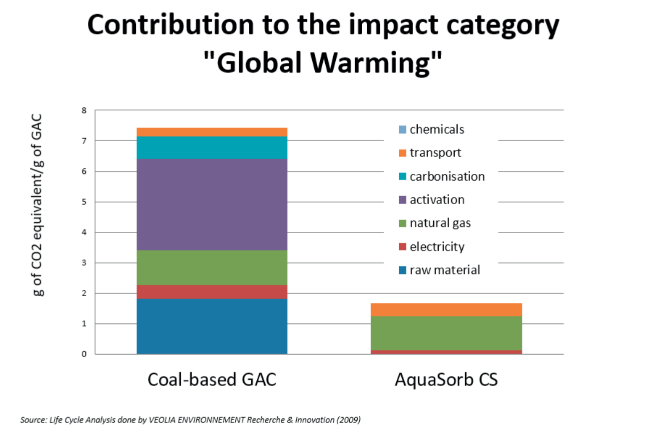
Results concerning the impact category « Global Warming »

They represent the amount of Greenhouse Gas (GHG) emitted directly and indirectly throughout the life cycle of the product. It is also commonly called the "carbon footprint" of the product.

Comparison in tons of CO_2 equivalent per ton of AC

The results are presented in table and graph below:

ACTIVATED CARBON	CONTRIBUTION TO GLOBAL WARMING (t CO_2 equivalent / t of AC)
Coal-based GAC	7,42
AquaSorb™ CS	1,69



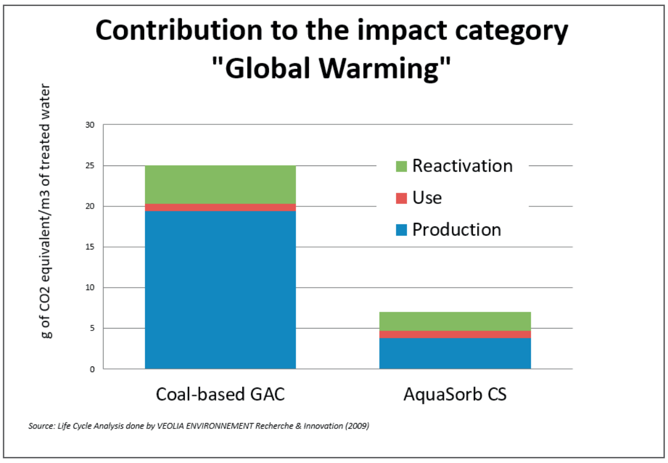
Coal-based GAC has a worse score than AquaSorb™ CS. The carbonization and activation steps generate direct CO_2 emissions due to the combustion of the raw material. In the case of coal-based GAC, this CO_2 is fossil, because the raw material itself has a fossil origin. In the case of AquaSorb™ CS, CO_2 is biogenic: it comes from the combustion of coconut that grew on a coconut tree that had previously captured atmospheric CO_2 to grow. The extraction of the raw material is also an important part of the GHG emissions of coal-based GAC.

Thus, the contribution to Global Warming of AquaSorb™ CS is more than 4 times lower than coal-based GAC.

Comparison in tons of CO_2 equivalent per cubic meter of treated water

These results take into account the GAC lifetime so as to evaluate the impact of carbon during its whole operation (and not only during the first fill).

The results are presented in the graph below:



Similarly, the results materialize very clearly the major impact of the consumption of non-renewable fossil raw material in the case of coal-based GAC.

Between the following two operational scenarios:

- Reactivation of AquaSorb™ CS every 20 months
- Reactivation of coal-based GAC every 20 months

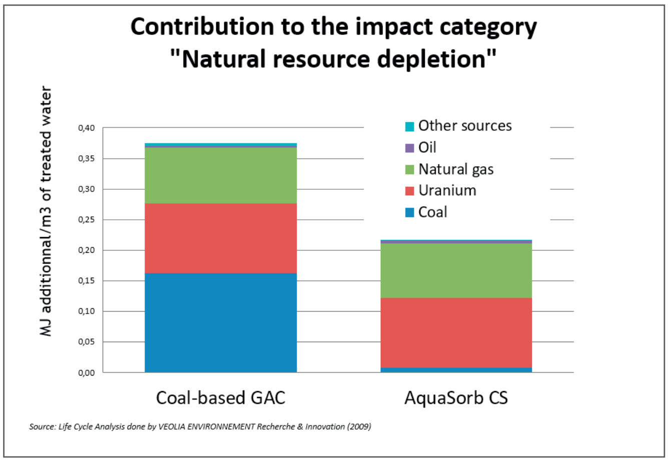
the contribution of AquaSorb™ CS to Global Warming is 70% smaller than that of a coal-based GAC, and, for the same function / efficiency.

Note : We have also studied the case where coal-based GAC is replaced by virgin coal-based GAC every 36 months.The contribution to Global Warming of AquaSorb™ CS (reactivated every 20 months) is still 70% smaller than that of coal-based GAC (replaced every 36 months).

Results for the impact category “Natural resource depletion“

They are expressed in megajoules (MJ) additional, representing the amount of extra energy that will be needed to extract the resource in the future. This impact category has two subcategories: the consumption of fossil fuels (oil, natural gas, coal etc..) and the extraction of minerals (iron, aluminum, etc..)

The results are presented in the graph below:



Impacts are largely dominated by the use of fossil fuels:

- Uranium consumption is the electricity needed to operate the AC in the drinking water plant (assuming water plant located in France).
- Natural gas is used during activation and reactivation.
- Oil is mainly consumed as fuel for transport phases.

For coal-based GAC, the extraction of coal - non-renewable fossil material - necessary for the production of this GAC is an important part of its impacts.

AquaSorb™ CS has less impact on natural resource depletion than coal-based GAC.

Results for the impact category "Damage to ecosystems"

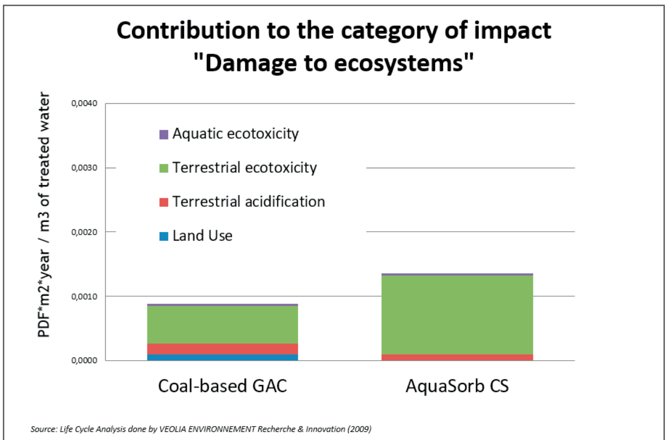
This impact category is the damage caused by the product on ecosystems. The unit used is: Potentially Disappeared Fraction x m^2 x year (PDF x m^2 x year) is the fraction of vascular plants that will probably not be present anymore on a given surface during a given period.

This impact category has four subcategories:

- Land use (expressed in m^2 of arable land occupied): in this case, we excluded the land use to grow coconuts.
- Terrestrial acidification (kg SO_2 eq)
- Terrestrial and aquatic ecotoxicity (kg of Triethylene Glycol equivalent (TEG eq)).

Environmental models can translate emissions of pollutants into impacts. Please note that these models contain some uncertainty , quite difficult to estimate at this time.

The results are presented in the graph below:



Terrestrial Ecotoxicity: The emissions of derivatives of acetic acid during the carbonization step are responsible for terrestrial ecotoxicity in the case of AquaSorb™ CS. For coal-based GAC, the extraction of the raw material is responsible for these impacts.

Terrestrial acidification: Land acidification is mainly caused by NO_x and SO_2 emitted by trucks or boats during the phases of transport.

Although coal-based GAC appears to have a lesser impact, the small difference between the values does allow to conclude.

Results for the impact category "Damage to human health"

This impact category is the damage caused by the product on human health. The unit used is the DALY (Disability Adjusted Life Year): the total number of years spent in poor health, and years of life lost, which were caused by the product.

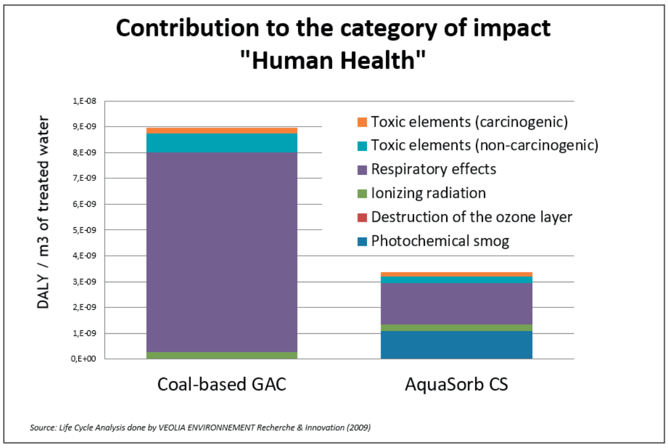
This impact category is divided into six subcategories:

- Photochemical ozone formation (expressed in kg C_2H_4 eq)
- Ozone depletion (expressed in kg CFC-11 eq)
- Ionizing Radiation (expressed in Becquerel C-14 eq)
- Respiratory effects
- Human toxicity carcinogenic and non-carcinogenic (expressed in kg C_2H_3Cl eq).

Environmental models can translate emissions of pollutants into impacts. Please, note that these models contain some uncertainty , quite difficult to estimate at this time.

Moreover, we must remember that the method was developed to assess the impacts generated in a European context. In some of the scenarios, the production of activated carbon is in Asia. The uncertainty of the results presented is therefore considerable. These results are provided for information only and should be used cautiously.

The results are presented in the graph below:



Respiratory effects: They are caused by the emissions in air of the following substances: particles, nitrates and sulfates, SO_2, O_3, CO and NO_x from the combustion of fossil fuels. For this study, it is due to the fuel for transportation and to the combustion of natural gas for activation.

In the case of coal-based GAC, the emissions due to the production of electricity needed to extract coal are responsible for 50% of these impacts: in coal mines, electricity comes from coal power plants. This is the reason why coal-based GAC presents a worse score than AquaSorb™ CS. The substances primarily responsible for these impacts are NO_x (from 54 to 57%), SO_2 (26-30%), and fine particles (<2.5 µm) (14-16%).

Photochemical ozone: The formation of photochemical ozone is caused by the emissions of derivatives of acetic acid during the combustion of coconut. These emissions are higher for the production of AquaSorb™ CS than for the production of coal based GAC.

AquaSorb™ CS has lower impact on human health than coal-based GAC.

Conclusion

Committed to Sustainable Development, Jacobi has launched in 2009 a Life Cycle Analysis of its activated carbons, carried out by Veolia Environnement Recherche & Innovation, in accordance with ISO 14000 principles. This study is a first in the “world of Activated Carbon.”

In support of this study, Jacobi recommends you to:

- Use AquaSorb™ CS (made from natural and renewable raw materials), which has a better environmental performance than coal-based activated carbon, widely used for drinking water production.
- Reactivate your spent GAC rather than replace it by virgin GAC,
- Recycle our spent GAC, rather than eliminating it.

These solutions can significantly improve the environmental impact of your drinking water plant: with up to 15% reduction of its global carbon footprint!

Moreover, these environmentally friendly solutions allow you to do savings. They don’t risk water quality nor impact the hydraulic operation of your plant.

Jacobi, together with many water treatment plants, have already replaced more than 7,000 m³ of fossil activated carbons with others made of vegetal, natural and renewable resources, equivalent to the water supply of almost 4 million people!

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