Drainage geocomposites: a considerable potential for the reduction of greenhouse gas emission

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ABSTRACT: Geosynthetic materials and in particular drainage geocomposites offer a constructive alternative to traditional solutions. In this period of global awareness of the need to protect the environment for future generations, it has become a matter of urgency to evaluate the impact of geosynthetic materials especially where the emission of greenhouses gasses is concerned. The use of geocomposite instead of granular layer permits to save up to 87% of equivalent CO2 emissions for equivalent hydraulic performances.

1 INTRODUCTION

The present study proposes an analytic approach to establish in the first instance the carbon footprint of geosynthetics. At the end of this study, which required in-depth investigation of emission factors related to the production of these materials, a comparative approach established the carbon footprint of so-called “traditional” construction solutions compared to those using drainage geocomposite materials.

2 THE GREENHOUSE GAS MECHANISM

The main greenhouse gasses are steam, carbon dioxide (CO2), methane (CH4), nitrous oxide (or nitric oxide with formula N2O) and ozone (O3). Industrial greenhouse gasses include heavy halocarbons (chlorinated fluorocarbons including CFC, molecules of HCFC-22 such as Freon and perfluoromethane) and sulphur hexafluoride (SF6). Greenhouse gasses are the main factors contributing towards global warming.

Greenhouse gasses are transparent at certain wavelengths of sun rays and thus allow these rays to penetrate deeply into the atmosphere or even attain the earth’s surface. The rays absorbed by the earth generate heat which is in turn returned to the atmosphere in the form of infrared rays. Greenhouse gasses and clouds prevent some of these infrared rays from escaping and trap them together with the heat they carry close to the earth's surface subsequently warming the lower atmosphere. Alteration of the natural barrier of atmospheric gasses may increase or decrease the average temperature of the planet.

Most greenhouse gasses are of natural origin such as steam or carbon dioxide. However, some are purely of human origin, or at least their concentration level in the atmosphere is directly related to human activity.

3 MEASUREMENT OF EMISSION LEVELS

There are several types of greenhouse gasses and their level of harmfulness varies. Rather than measure the emission levels of each gas, a common factor is used: CO2 or carbon equivalent.

The CO2 equivalent is also referred to as global warming potential (GWP). The value of 1 is given to carbon dioxide and used as a reference. The global warming potential of a gas is a factor which must be multiplied by its weight in order to obtain the CO2 weight required to have the same impact on the greenhouse gas effect. For example, methane has a GWP of 23 which means that its warming capacity is 23 times higher than that of carbon dioxide.

To obtain the carbon equivalent, one assumes that 1 kg of CO2 contains 0.2727 kg of carbon. Emission of 1 kg of CO2 is therefore equivalent to 0.2727 kg of carbon. For other gasses, the carbon equivalent is: PRG x 0.2727.

It may be noted that the combustion of one ton of carbon corresponds to the emission of one ton of the carbon equivalent of CO2.

This measurement unit is very useful to determine the levels of emission of a specific factory for example. It is therefore possible to establish a global footprint which takes into account direct (combustions, energy consumption, transports) and indirect (production and transport of sub-contracted products) emissions.

4 GLOBAL EMISSION OF THE COMPAGNY

4.1 *Study, methodology and procedure*

The company AFITEX, manufacturer of drainage geocomposites, has undertaken a study of its industrial site in Champhol (France) to establish the global extent of its carbon footprint, i.e. including not only the direct emission levels of the site, but also the indirect emissions such as:

- The manufacture of products and materials used in production (including packaging),
- Transport from the supplier's works to the site,
- Internal transport of goods,
- Professional travel of employees, such as travel from home to work and back again,
- Processing of directly generated waste (waste in the waste bins on site) or indirectly generated waste (product packaging),
- Construction of buildings used,
- Manufacture of the machines used,
- The emissions associated with the end of life of products.

The study was carried out using the "carbon footprint" method developed by ADEME. The period taken into account for the calculation of emissions is the financial year 2008.

4.2 *Extract of the calculation method*

The plastic fibres purchased are either of top grade or second grade as they are not made of recycled waste. The percentage of recycled material in the plastic is therefore considered to be zero.

As the emission factor of PP (polypropylene) is not available in the software package, the emission factor "Plastic – medium" was used. This would appear to artificially increase the emission level of the company.

In fact, this emission factor is 20% higher than the other plastics used and represents 82% of the incoming tonnage.

The data relative to the purchase of services and supplies was based on analytic compatibility.

Low material services: laboratory tests, design services, maintenance of premises, insurance, accounting fees, lawyers, HR, technical evaluations, patents, certificates, public relations, trade fairs and exhibitions, telephone, training.

High material services (supplies): office supplies, catalogues and printed matter, rental of forklift trucks, maintenance and workshop equipment, needles.

Rentals and equipment are listed as fixed assets.

To calculate the road transport of suppliers, considering its moderate impact on the total carbon footprint, all supplies will be calculated in tons/km based on the weight purchased for each product and the distance from the supplier's site.

The purchase of computer equipment (fixed assets) and computer consumables (printing ink cartridges) was calculated separately.

The home-to-work travel value is based on the distance from the company site to the home.

Professional travel is based on the commercial contract and expenses reimbursed.

The options retained in the present study enable comparison of the greenhouse gas emission levels for the various drainage methods over an equivalent perimeter, i.e. including:

- Emissions due to the products up until the time they leave the factory;
- Emissions due to transport from the factory to the work site;
- Emissions due to use of the products on site.

The rate of incertitude of these results is 20% and is due to the level of incertitude of the emission factors.

4.3 *Global emission of the compagny*

Table 1 shows the repartion of equivalent CO2 emissions function of the identified sources in order of importance.

Table 1: Sources of emissions in order of importance

Emission point in order of importance	Emissions (tons of GHG eq. CO_2)	
Plastics and incoming goods	**5 585**	**82%**
Transport from suppliers	**474**	**7%**
Travel of employees	195	2,9%
Fixed assets: buildings and machines	150	2,2%
Packaging materials	124	1,8%
Natural gas supply	100	1,5%
Product end of life	80	1,2%
Electrical supply	64	0,9%
Coolants	12	0,2%
Direct waste	7	0,1%
TOTAL	**6 791**	

The total of direct and indirect emission of the compagny in 2008 was 6,791 tons of equivalent CO2.

The incoming plastics, materials and services represent the largest proportion of these emissions.

For a second transformation of the plastics, the compagny adds 22% to the emissions due exclusively to the processing of incoming materials.

5 ANALYSIS COMPARED TO CONSTRUCTIVE SOLUTIONS

The SOMTUBE and DRAINTUBE drainage geocomposite ranges offer a complimentary solution and an alternative to the use of quarry gravel for drainage applications.

A software package has been developed using the results of the AFITEX carbon footprint study and emission factors.

This tool is used to compare several technical solutions: The various geocomposites associated with the various processes and thickness of gravel layers.

The results are calculated in CO2 emission per square meter or linear meter of drainage application.

There are 4 types of drainage applications either using traditional solutions or geosynthetics systems:

- Construction: drainage under concrete paving,
- Roadwork: roads, drainage under topsoil,
- Roadwork: drainage along roadsides
- Waste dumps: drainage at bottom of pit

5.1 *Methological process*

The drainage system may comprise any of the following stages depending on requirements:

- Earth removal work,
- Topsoil work,
- Transport of excess earth,
- Extraction of gravel from the quarry,
- Transport of the gravel to the work site,
- Application of the gravel on site,
- Traditional plastic drains: Manufacture, transport, installation,
- Sealing membrane: Manufacture, transport, installation,
- Geocomposite product (filter, layer, mini-drains): Manufacture, transport, installation.

Work carried out on site takes into account the machinery used (fuel without material) and labour.

The emission factors (materials, transports, fuel, services) are taken from the carbon footprint results established beforehand. As products are manufactured with plastic, their emission levels are calculated according to the total weight of each product per square meter in order to simplify the calculation.

The emission factor corresponds to the most global scope of the study, i.e. includes all emissions of the entire manufacturing chain up until leaving the factory.

The quantities required for each of these operations were provided by the manufacturer's design office or from a public roadwork operator.

5.2 *Description of the various applications examined*

The drainage geocomposites may be used to totally or partially replace the granular materials as well as the filtering and anti-puncture geotextiles.

Figures 1 to 4 present the fourth applications studied.

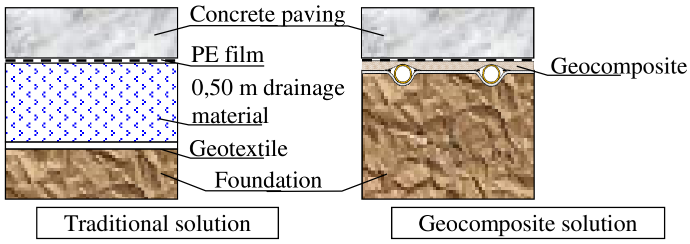

Figure 1. Drainage under pavement

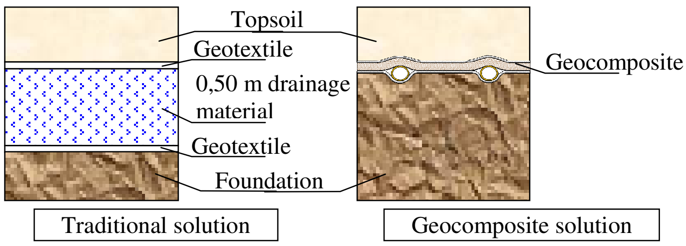

Figure 2. Drainage under embankment

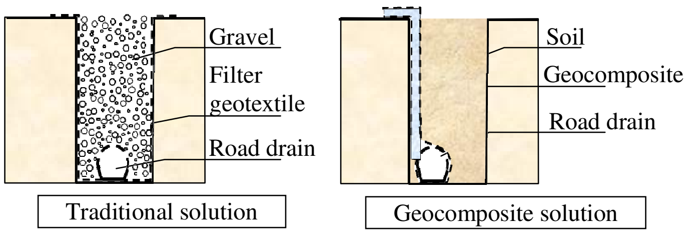

Figure 3. Drainage screen along roadside

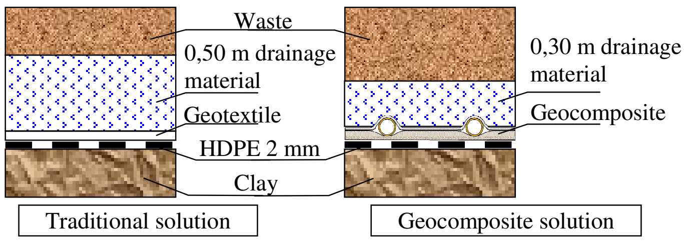

Figure 4. Drainage at bottom of landfill

5.3 *Case study: Drainage under embankment*

The present paragraph presents a case study for drainage under topsoil. The traditional solution composed of geotextiles and 50 cm layer of granular material is replaced by a single geocomposite.

Table 2 presents the calculation of emissions in CO2 eq. for a 50cm thick traditional granular drainage layer.

Table 2. Calculation of emissions in CO2 equiv. for a 50cm thick traditional granular drainage layer

	quantity	unit	Kg CO_2 eq./m2
QUARRY GRAVEL			
Gravel density	1,8	tons/m3	
Gravel thickness	0,50	m	
Tons of gravel extracted for 1 m2	0,9	tons	13,050
Transport of gravel			
distance from quarry to worksite	15	Kms one way	
Number of kms for 1 m2	0,675	kms	0,728
Application of gravel using site machinery			
Tons of gravel applied per hour	65	tons	
hours of work for 1 m2	0,014	hours	
Fuel consumption per hour	40	litres	
Fuel consumption for 1 m2	0,553	litres	1,630
Application of gravel			
Labour costs per hour	30	euros	
Number of workers	2		
euros for services for 1 m2	0,831	euros	0,030
GEOTEXTILE			
Weight per square metre	0,15	kg	0,286
Transport from manufacturer to worksite			
Distance to worksite	500	kms	
Transport of products	0,075	Tons/km	0,019
Application of the product on site using machinery			
m2 applied in 1 hour	571	m2	
Fuel consumption per hour	20	litres	
Fuel consumption per m2	0,035	litres	0,103
Product application (labour)			
Labour costs per hour	30	euros	
Number of workers	3		
euros for services per m2	0,1575	euros	0,006
		TOTAL	**15,852**

Table 3 presents the calculation of emissions in CO2 eq. for geocomposite drainage.

Table 3. Calculation of emissions in CO2 eq. for geocomposite drainage

	quantity	unit	Kg CO_2 eq./m2
EMBANKMENT			
Landfill of topsoil using site machinery			
Tons of earth filled per hour	250	tons	
hours of work for 1 m2	0,004	hours	
Fuel consumption for 1 m2	0,24	litres	0,706
Landfill of topsoil (machinery and truck driver labour costs)			
euros for services for 1 m2	0,36	euros	0,013
GEOCOMPOSITE			
Name of product	Somtube FTF		
Weight per square metre	0,668	kgs	2,234
Transport of AFITEX product to site			
Distance to worksite	500	Kms one way	
Transport of products	0,334	Tons/km	0,086
Application of the product on site using machinery			
m2 applied in 1 hour	571	m2	
Fuel consumption per hour	20	litres	
Fuel consumption per m2	0,035	litres	0,103
Product application (labour)			
Labour costs per hour	30	euros	
Number of workers	3		
euros for services per m2	0,1575	euros	0,006
		TOTAL	**3,148**

The geosynthetic solution enables a reduction by 80% of CO2 equivalent emissions. The 2 processes calculated were equivalent from a functional viewpoint.

5.4 *Results for the averall applications*

The table 4 indicates the emissions in CO2 equivalent for the 4 applications proposed and compares the emissions between the traditional solution and the geocomposite solution.

Table 4. Emissions of CO2 equivalent

Application	Description		Emission (eq.CO_2)	Emission reduction
Drainage under concrete paving	Traditional solution	0,50 m drainage materials + geotextile filter + polyethylene film	24,28 kg (CO_2 / m²)	**87%**
	Geocomposite solution	Geocomposite only	3,23 kg (CO_2 / m²)	
Drainage under embankment	Traditional solution	0,50 m drainage materials + geotextile filter	15,85 kg (CO_2 / m²)	**80%**
	Geocomposite solution	Geocomposite only	3,15 kg (CO_2 / m²)	
Drainage screen along roadside	Traditional solution	Drainage material trench, width 0,50 m and depth 0,80 m	40,69 kg (CO_2 / ml)	**69%**
	Geocomposite solution	0,30 m drainage material + geocomposite	12,79 kg (CO_2 / ml)	
Drainage under waste disposal landfill	Traditional solution	0,50 m drainage material + anti-puncture geotextile	21,55 kg (CO_2 / m²)	**26%**
	Geocomposite solution	0,30 m drainage material + geocomposite	16,01 (kg (CO_2 / m²)	

Use of a geosynthetics solution offers a considerable reduction of CO2, emission between 26% and 87% depending on the applications. This reduction is directly related to the quality of the drainage materials substituted and the saving in earth moving work. Indeed, to drain the bottom of a waste pit, the drainage material is only partially substituted (substitution of 20 cm of the initial thickness of 50 cm) and the emission reduction is consequently lower in this case i.e. 26%.

On the other hand, when draining under paving, the entire granular layer is substituted together with the associated earth work and thus offers an emission reduction of 87%.

6 CONCLUSIONS

The present study illustrates the interest in recommending constructive solutions using drainage geocomposites rather than granular materials which represent a high level of consumption of fossil fuels with subsequent emission of greenhouse gasses.

Contrary to general belief, oil-based geocomposites do not generate more greenhouse gasses than traditional methods. On the contrary, geocomposites help reduce global emissions and is perfectly compatible with a sustainable development strategy.

Furthermore, drainage geocomposites help avoid alteration of the landscape due to the exploitation of quarries and offer a constructive solution when granular materials are not available close to the construction site. It therefore offers a reliable alternative in sectors such as roadwork, environment, building construction and mining.