CHARACTERISATION OF BIOWASTE TREATMENT PLANT LEACHATES – TOWARDS ENVIRONMENTAL IMPACT ON SURFACE AND GROUNDWATER

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Abstract

Based on a regional scale study on Walloon biowaste treatment plants, liquid and gaseous emissions from biowaste composting and biomethanation plants have been characterised by ISSeP, the scientific institute working for the Walloon Government. ISSeP has determined the pollution loads of compost leachate and anaerobic digestion process liquid based on about 50 analytical results distributed over 24 treatment plants. On several levels, all the parameters are detected in ranges of concentrations higher than the drinking water standards. A leaching pattern has been defined, including the most relevant parameters (tracers) detected in biowaste compost leachate: TOC, ammoniacal nitrogen, total phosphorus, iron, chemical oxygen demand (COD) and some micropollutants such as dichlorobenzamide, diuron, toluene and phenanthrene. The liquids sampled in the anaerobic digesters showed higher contents of pollutants than compost leachates, especially for carbon-based parameters, phosphorus and mineral oil.

Defining such leaching patterns can be very helpful for monitoring surface water and/or groundwater in case of accidental leakage of leachate.

1- INTRODUCTION

Wallonia -through its efficient management plan- is in the leading group in Europe in terms of sorting and recycling domestic waste and assimilated waste. Its regional policy falls within the European Framework Directive on Waste approved on November 2008, which imposes the following hierarchy in waste prevention and management: prevention, preparing for re-use, recycling, other recovery (e.g. energy recovery) and disposal. In this respect, Wallonia has settled various regulatory tools (legislative, financial, informational) to reduce waste production and to promote ways of dealing with the best "costs vs environmental benefits" ratios. All the governmental objectives are gathered into a single strategic document, the "Walloon Waste Plan" (WWP), which is updated every 10 years. Recently, the Administration assessed the first WWP efficiency (WWP "Horizon 2010") over the past decade, through the lens of its objectives. It highlighted that the availability of "biowaste" through selective collection increased progressively since 2008, when the landfilling of biomaterials, green waste and organic fraction has been prohibited. The first direct consequence of this measure is a 40% decrease of the amount of dumped household waste in 3 years, from 3,4 million tons/year in 2008 to 2 million tons/year in 2011. Another important consequence is the development of other waste treatment schemes such as recycling or energetic valorisation. The environmental surveying mission of ISSeP was initially dedicated to the monitoring of Walloon municipal solid waste landfills; it has naturally evolved towards the study of emerging treatment processes and more specifically composting and biomethanation plants.

This paper presents the work achieved by ISSeP following 3 successive steps: the definition of the study scope and the site selection criteria (location, treatment capacity, and allowed feedstock), site-by-site study (administrative and cartographic data collection, field investigation, sampling, evaluation of environmental sensitivity, reporting) and finally overall and cross-sectional study at the regional scale (assessment of environmental impact).

2- METHODS

The study focuses on composting and biomethanation plants located in Wallonia (south part of Belgium). For composting plants, treatment capacities only higher than 500 m³ are considered, including class 1 (higher than 40.000 m³) and class 2 (between 500 and 40.000 m³) installations. Up to now, there are no class 1 facilities on the Walloon territory. Regarding anaerobic digestion, biogas production sites exceeding 100 Nm³/h are excluded as well as biogas production from water treatment plant sludge. The feedstock is typically green waste, waste from the food industry, sorted household waste from the selective collection and municipal organic waste. For every site, ISSeP collects administrative information (operating authorisation, license to use the final products, i.e. compost and digestate...), any previous studies (environmental impact assessment, olfactory impact study ...) and all the analytical and environmental data available from the operator. In the meantime, a GIS file is created. ISSeP then visits the plants in order to get eventual additional information and to better apprehend the field situation. Technical reports are then compiled for every plant, including the data collected and the visit reports. These technical documents are integrated into a cross-sectional assessment which is used to classify the sites according to an absolute "environmental sensitivity scale". The level of sensitivity takes into consideration not only potential sources of pollution, but also their vectors and their targets (residents, surface and groundwater, protected natural areas). Targeted water and/or air sampling campaigns are then organised; sampling procedures, chemical analyses and data treatment are given in ISSeP reports and proceeding [1,2,3]. Although related to landfill site characterisation, the so described methods have been applied successfully on the investigated biowaste treatment plants.

The third and final part of the ISSeP work is a cross-sectional study encompassing all the results and conclusions of every single site. Some statistical parameters are calculated at a regional scale in order to characterise the pollution loads of compost leachates and liquids produced during the anaerobic digestion. These figures are used to establish the chemical signature (leaching pattern) of those process liquids allowing efficient monitoring in case of leakage in surface water or groundwater.

Physicochemical characterisation of final products (compost, biogas and digestate) obtained after the aerobic or anaerobic transformations is not discussed here.

3- RESULTS AND DISCUSSION

Step I. Until January 2012, 24 Walloon biowaste treatment plants are included in ISSeP's study. They fall into three categories as follows: 18 composting plants, 4 biomethanation plants and 2 treatment sites with both processes.

Among the composting facilities, 16 are treating green waste exclusively while 2 receive waste from the food industry in addition to green waste (co-composting). Three different categories of biomethanation plants are defined: biomethanation of agricultural waste, biomethanation of biogenic waste (separated organic fraction of household waste) and biomethanation of waste from the food industry.

Step II. Over a two years period (2010-2011), ISSeP provided 15 "*technical reports*", leading to the following general conclusions:

- It seems that composting plants are on average more sensitive than biomethanation ones from an environmental standpoint.
- The amount of potentially polluting liquids is higher on composting plants; the open-air areas for biowaste storage (during pre-treatment, fermentation and maturation) that are submitted to rainfall are generally larger compared to biomethanation plants.
- Leachate of compost and runoff water are not always easy to collect properly.
- Odour management is more complicated on composting plants. Compost odours diffuse through larger work areas, especially during handling of compost material. On the other hand, odours produced on biogas plants can be channelled into pipes for biogas transportation or chimneys for the evacuation of flue gases.
- In addition to the odorants, repeated manipulations of biowaste during the composting process (grinding, turning windrows for aeration, sieving ...) generate dust, bioaerosols and chemicals. Their emission must be controlled to avoid any health impact on workers.

According to each site-specific situation, leachate, biomethanation process liquids, surface water and/or groundwater samples have been collected on the sampling points identified during the preliminary visits. Results of water analyses, as well as their interpretation, are presented in "*environmental situation reports*" written for each site individually. Those reports also include odour impact assessment and ambient air quality assessment when available.

It is not relevant to detail individual results or problems highlighted in these reports, and moreover some of them must remain confidential. However, some general observations may be given as follow:

- Most of owners are involved in the strict eco-management and audit scheme (EMAS). Working conditions and monitoring programs are implemented to prevent any chronic problem. Even when the location of the exploitation may be considered as very sensitive from an environmental standpoint, ISSeP never observes any significant impact on the receptors (surface water and groundwater).

- Odour problems are common during the first years of operation. They are now less frequent due to the ongoing efforts to improve work processes and implementation of techniques to reduce odours combined with constructive communication between residents and owners.
- Accidental risk is the most relevant one, especially for liquid emissions. Being prepared for an intervention in case of major leachate leakage should remain the principal environmental concern for owners of biowaste treatment plants.

Step III. ISSeP firstly focuses its interpretative work on the chemical characterisation of liquid emissions with the aim of defining an average composition of Walloon compost leachate and biomethanation process liquids. Although similar studies have been already conducted in other countries [4-8], ISSeP's experience on MSW landfills shows that significant differences in leachate composition are observed, even at a regional scale. Table 1 presents the statistical parameters calculated from 13 chemical compositions of composting leachates and the average composition for 2 biomethanation process liquids. As an indication, the last columns of Table 1 give the typical MSW landfill leachate composition in Wallonia [1] (column 6) as well as groundwater quality standards around landfills. When not available for groundwater, standards for WWTP discharge on landfill sites or reference values for surface water are given [9] (column 7).

The comparison of the chemical signature of landfill leachate to the one of biowaste treatment plant emissions is meaningful insofar as organic waste was dumped into landfill until 2008. Focusing first on compost leachate, this comparison leads to the following observations:

- The organic indicators (BOD5, COD, TOC) for landfill leachate and compost leachate are in the same ranges of values.
- The concentrations of nitrogen-based molecules are significantly lower in compost leachate compared to landfill leachate while the total phosphorous content is two times higher.
- Sulphates and chlorides are about ten times more concentrated in landfill leachate, while cyanides are only two times higher.
- Among the metals, nickel predominates in both leachates as well as copper in the compost leachate and chromium in MSW landfill leachate.

ISSeP has also analysed different families of organic micropollutants but only few results are higher than detection limit so that it is not possible to compute any robust statistics. Traces of BTEX are sporadically detected but never above 10 micrograms per litre, which is not so different from landfill leachate values. Concentrations of polycyclic aromatic hydrocarbons (PAH) are even lower: most of the concentrations remain under 0,500 µg/l. This is not true for one site where a leakage of mineral oil from an unknown origin occurred just before the sampling, giving much higher PAH concentrations. Phenanthrene is the predominant derivative of PAH group (median: 0,472 µg/l, P10-P90: 0,035-0,817).

PCB’s are not detected in leachate collected from Walloon composting plants.

Twenty-five pesticides have been also analysed. Indeed, an accumulation of such organic compounds can be suspected in compost leachate due to the recirculation of the leachate through the windrows of green waste compost. The owners often resort to this process in order to maintain a constant humidity rate in the material. Only two of them are detected however: dichlorobenzamide and diuron for which detection rates reach respectively 100% and 64%. Moreover, the differences observed from one site to the other are not correlated to the closed-circuit leachate management, the concentrations being not significantly higher on the sites where it is applied. Nevertheless, it must be stressed that the current analytical techniques are lagging behind the new families of pesticides that are flooding the market in place of now prohibited molecules.

Parameters	Unit	Compost leachate		Biomethanation process liquid	Landfill leachate [1]	Reference values for groundwater quality [9]
		Median	P10-P90	Average	Median	
BOD5	mg O_2/l	140	23-1.465	2.591	229	90*
COD	mg O_2/l	1.658	353-6.120	23.388	2.439	300*
TOC	mg/l	1.000	69-2.474	8.418	792	5
AOX	µg Cl/l	408	103-860	382	1.214	100
N_{NH4}	mg N/l	29	1-338	151	615	0,5
NO_3	mg N/l	0,011	0,011-0,84	0,123	0,87	11,3**
P_{tot}	µg/l	19.338	5.940-34.500	137.057	8.340	1.150
Cl^-	mg/l	193	73-799	255	1.610	150
CN^-_{tot}	µg/l	13,8	1-136	24	26,6	50
$SO_4^=$	mg/l	28	7,5-112	98	184	250
As_{tot}	µg/l	25	6,5-70	24	59,3	10
Cd_{tot}	µg/l	0,81	0,25-3,1	2,7	0,84	5
Cr_{tot}	µg/l	17,5	4-72	25,9	382	50
Cu_{tot}	µg/l	42	10,3-130	86	23	100
Fe_{tot}	µg/l	6.070	1.654-32.213	29.092	6.651	1.000
Hg_{tot}	µg/l	0,025	0,025-0,19	n.d.	-	1
Mn_{tot}	µg/l	927	217-2.750	4.956	803	250
Ni_{tot}	µg/l	40	7,5-111	35,5	136,7	20
Pb_{tot}	µg/l	28	3,15-85	41	10	10
Sn_{tot}	µg/l	n.d.	n.d.	n.d.	87,3	5
Zn_{tot}	µg/l	189	96-1.142	1.619	135	200

Table 1: Statistics (median, percentile 10 and 90) and average values for liquid emissions produced on composting and biomethanation plants for some relevant parameters (WWTP discharge standards;** Surface water reference values)*

The composition of process liquids sampled in the anaerobic digesters (Table 1, column 5) shows some particularities:

- The pollution load is higher in biomethanation process liquid compared to compost leachate.
- The highest differences are registered for carbon-based parameters (COD, TOC, BOD) and phosphorous.
- The mineral oil indexes (GC C_{10}-C_{40} and C_{05}-C_{11}) are particularly high.

The external water intake (rainfall) on composted materials during a longer time probably explains the higher dilution of compost leachates. Digesters often work with a few added water or without any at all; the amount of humidity coming from biowaste is usually sufficient to make them work properly. These above observations need to be confirmed, with additional results coming from other biomethanation plants. Anyway, both the compost leachates and the biomethanation process liquids are characterised by a pollution loads that exceeds the standards or reference values given in the last column of Table 1. In Table 2, chemical tracers included in the leachate pattern are classified according to the ratio "R" between their median value and the reference value. Taking detection rate into account, some micropollutants could be added to this leachate pattern, per order of relevancy: dichlorobenzamide, diuron, toluene and phenanthrene.

	TOC	N_{NH4}	P_{tot}	Fe_{tot}	COD	AOX	Mn_{tot}	Pb_{tot}	As_{tot}	Ni_{tot}	BOD	Cl^-	Zn_{tot}	Cu_{tot}
R	200	58	17	6,1	5,5	4,0	3,7	2,8	2,5	2,0	1,6	1,3	0,95	0,42

Table 2: Chemical signature of compost leachate -
Classification based on "R" ratio = median concentration in leachate / Reference value

4- CONCLUSIONS

In 2010, ISSeP began to examine the environmental situation of "biowaste" recovery processes, i.e. composting plants and biogas production plants. A total of 24 treatment plants have been submitted to specific environmental investigations and samplings both on water and air domains. This paper reports on the characterisation of pollution loads in compost leachate and in biomethanation process liquids. A leaching pattern of these emissions has been defined, which can be useful to detect some abnormality in the composting and biomethanation processes or to monitor the quality of the receptors (surface and groundwater) in case of accidental leachate leakage in the surroundings. Relevant tracers for compost leachate are TOC, ammoniacal nitrogen, total phosphorus, iron, chemical oxygen demand (COD) and some micropollutants such as dichlorobenzamide, diuron, toluene and phenanthrene. Generally speaking, it must be stated that operators are aware of environmental issues. They develop intervention programs to avoid any accident and make every effort needed to limit the impact of their activities on potential receptors (workers, residents, natural areas).

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