Sustainable wastewater treatment of temporary events: the Dranouter Music Festival case study

S. W. H. Van Hulle, W. Audenaert, B. Decostere, J. Hogie and P. Dejans

ABSTRACT

Music festivals and other temporary events, such as bicycle races, lay a heavy burden on the surrounding environment. Treatment of the wastewater originating from such events is necessary if no municipal treatment plant is available. This study demonstrated that activated carbon is a performant technique for the treatment of wastewaters originating from these temporary events. Freundlich isotherms and maximum operational linear velocity (6 m/h) were determined on a lab-scale set-up. A pilot-scale set up was used to treat part (5%) of the total volume of the Dranouter Music Festival shower wastewater. On average 90% removal of COD and suspended solids concentration was obtained. Application of the activated carbon filter resulted in the fact that the local discharge limits were met without operational problems.

Key words | activated carbon filtration, sustainability, temporary wastewater treatment

S. W. H. Van Hulle
W. Audenaert
B. Decostere
J. Hogie
P. Dejans
Research Group EnBiChem,
Department of Industrial Engineering and Technology,
University College West Flanders,
Graaf Karel de Goedelaan 5,
B-8500 Kortrijk,
Belgium
E-mail: *Stijn.Van.Hulle@Howest.be*

INTRODUCTION

Music festivals and other temporary events, such as bicycle races, lay a heavy burden on the surrounding environment. For example, the Dranouter Music Festival (www.folkdranouter.be), organised in the south–west region of West Flanders (Belgium), accommodates 75,000 people over a period of 3 days. The water used by these 75,000 people (on average 400 m^3 over a period of 4 days) is currently directly discharged to the nearby Douvebeek river because the festival area is not connected to a wastewater treatment plant. Obviously the water quality in the river decreases dramatically because of the festival, as can be illustrated in Figure 1. This Figure shows dissolved oxygen measurements in the 2006 summer period performed by the Flemish Environment Agency (www.vmm.be). The effect of the Dranouter Music Festival (August 4th–6th) is clearly visible.

Because of this environmental concern, treatment of this water is necessary, yet difficult to accomplish. Conventional activated sludge processes will not start-up and operate stable on a 3 days period, reed beds are too coarse for filtration of the water and will also not be fully operational after 3 days. Sand filtration requires too much control and operational equipment such as a heavy back flush pump. Membrane filtration requires too much surface and pumping equipment. As such only activated carbon filtration is suited for treating festival wastewater. The goal of this paper is to evaluate this technique for treatment of wastewater originating from temporary events.

MATERIAL AND METHODS

Activated carbon

Two types of activated carbon, Airpel 10 and Organosorb 10 supplied by N.V. Desotec (www.desotec.com) were tested. Organosorb 10 is an activated carbon especially developed for the purification of wastewater. Airpel 10 is an activated carbon developed for the purification of air, but was tested in this study because of its structure. It was

doi: 10.2166/wst.2008.530

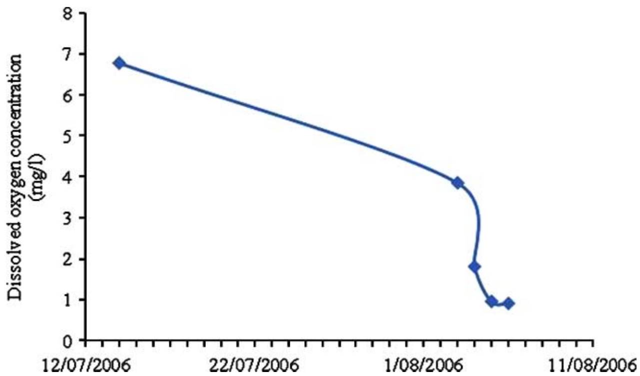

Figure 1 | Dissolved oxygen concentration in the wastewater receiving Douvebeek before and during the Dranouter Music Festival (August 4th–6th).

expected, because of the unknown composition of the wastewater, that less clogging would occur with Airpel 10, consisting of extruded pellets, than with Organosorb 10, which consists of granular activated carbon. An overview of the characteristics (Thomas & Crittenden 1998) of both activated carbon types is presented in Table 1. Data in this table was made available by N.V. Desotec.

A Freundlich isotherm (Metcalf & Eddy 1991) for the adsorption of festival wastewater was determined at 20°C for both activated carbon types. For the this experiment real shower water was used with a COD concentration of 221 mgCOD/l.

Optimal residence time determination

A lab scale activated carbon filter with a diameter of 2.54 cm and an activated height of 1.5 m was used to determine

Table 1 | Characteristics of activated carbon types used in this study

Parameter	Organosorb 10	Airpel 10
Total BET surface (m^2/g)	1,020	1,020
Iodine number (mg/g)	1,010	990
Methylene blue number (mg/g)	210	
CTC (%)		64
Hardness (%)	96	98
Density (g/l)	470	500
Water content (%)	3	2
Particle size (mesh)	12 × 40 (1.7–0.425 mm)	
Pellet diameter		3

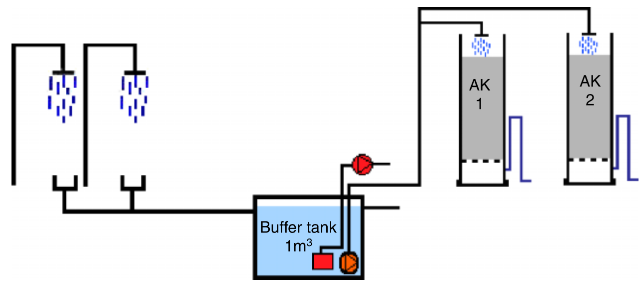

Figure 2 | Schematic overview of the experimental pilot scale set-up.

the optimal residence time in the activated carbon filter. The filter was operated at different residence times and corresponding filter velocities by altering the recycle pump flow rate. Real shower water was used with a COD concentration of 221 mgCOD/l.

Pilot scale set-up

For the pilot scale tests at the Dranouter Music Festival 2 activated carbon filters with a diameter of 31 cm and an activate height of 1.5 m were used. One filter was filled with Organosorb activated carbon, the other was filled with Airpel activated carbon. A flow rate of 400 l/h per filter was maintained during the festival. As such about 5% of the total festival wastewater was treated. A schematic overview of the experimental pilot scale set-up is presented in Figure 2.

Chemical analysis

All chemical analysis were performed according to standard methods (Standard Methods 1992)

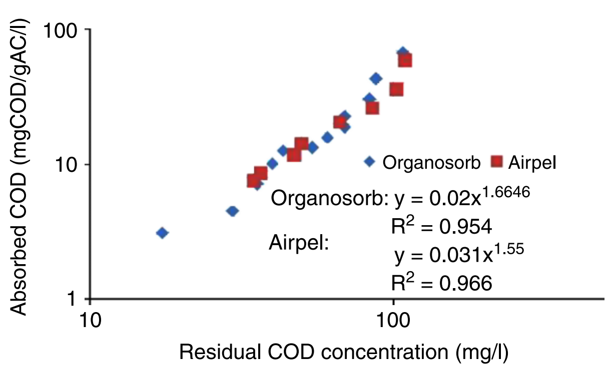

Figure 3 | Freundlich isotherms for the adsorption of festival wastewater of both activated carbon types.

Table 2 | Freundlich parameters for shower wastewater determined for the activated carbon types used in this study

Parameter	Organosorb 10	Airpel 10
A	0.02	0.03
B	1.6646	1.5513

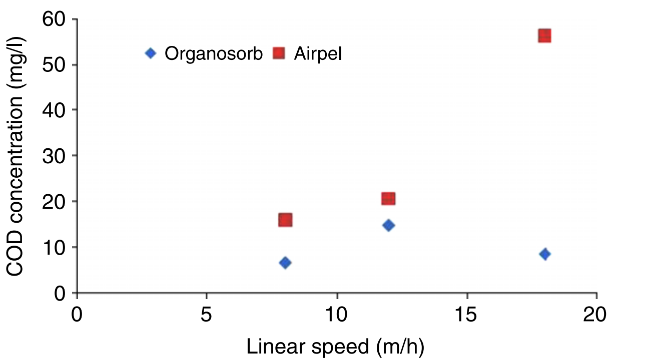

Figure 4 | Effluent COD concentrations in the lab-scale tests as function of the linear speed in the column.

RESULTS AND DISCUSSION

Isotherm determination

The results of the isotherm tests are depicted in Figure 3. It can be seen that both activated carbon types have a similar absorption behaviour, although Organosorb has a slightly higher capacity.

Further the Freundlich isotherms were determined for both activated carbon types. This isotherm expresses the relation between the concentration of organic matter (X, expressed as mgCOD/l) adsorbed by the activated carbon (m, expressed as gAC) and COD equilibrium concentration (c, expressed as mgCOD/l) in the wastewater:

$$\frac{X}{m} = ac^b$$

The Freundlich isotherm is widely used for a variety of heterogeneous adsorption systems because it gives more accurate results than the Langmuir isotherm (Chen & Horan 1998). In Table 2 the Freundlich parameters a and b are given. The obtained values are different from the ones obtained by e.g. Amuda & Ibrahim (2006), who investigated the adsorption efficiency of different activated carbon types in view of removal of organic matter from industrial wastewater. Also Shawwa *et al.* (2000) obtained different parameters.

Optimal residence time

The results from the lab-scale tests are presented in Figure 4. In this figure the effluent COD concentration of the lab-scale activated carbon filter is related to the linear speed in the filter. It can be seen that for a linear speed of 8 m/h a COD removal of 97% is obtained for the Organosorb type activated carbon, while 92% removal is obtained for the Airpel type activated carbon. For higher linear speeds the COD removal with the Organosorb type activated carbon remains constant, but the COD removal with the Airpel type activated carbon gradually increases.

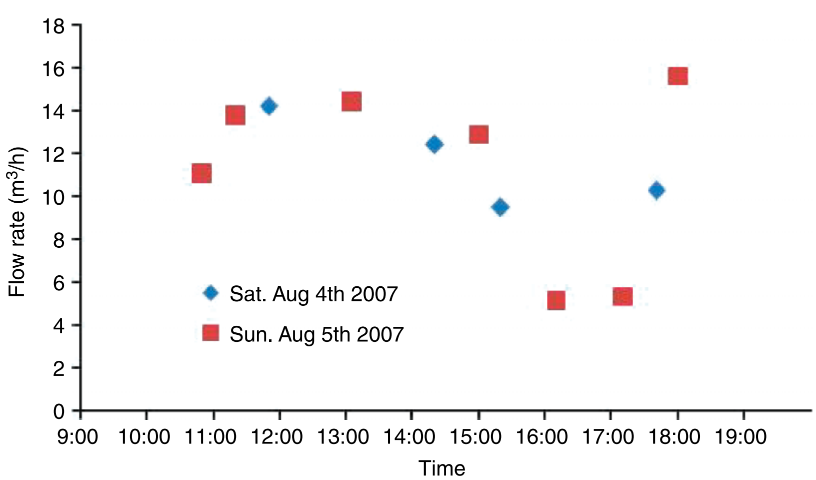

Figure 5 | Daily total flow rate of the Dranouter Music Festival wastewater (about 5% was treated in the pilot set-up).

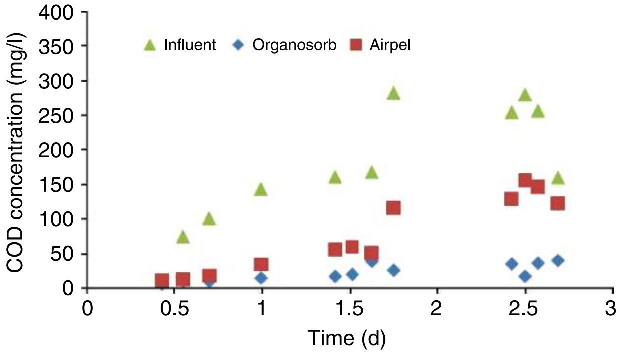

Figure 6 | Influent and effluent COD concentrations during the experimental period.

Increasing the linear speed in the activated carbon filter containing Organosorb above 8 m/h induced a water layer above the filter, indicating that the filter could not handle the flow rate, although sufficient removal was obtained. Because of this, a linear speed of 6 m/h through the activated carbon filters was chosen to guarantee adequate operation of the filter during the festival period. As such this linear speed was adopted in the pilot scale tests at the festival.

Pilot plant

The activated carbon filter was operated during the 4 days festival. The daily total flow rate is presented in Figure 5. Of this flow rate about 5% was treated in the pilot set-up the rest of the wastewater was discharged to the Douvebeek.

In Figure 6 the influent and effluent COD concentrations during the experimental period are depicted. It can be seen that breakthrough of the activated carbon filter containing Airpel occurred the third-day, which led to a violation of the discharge limits. The activated carbon filter containing Organosorb stays well below the discharge limits. Further, no clogging occurred during that period.

Table 3 | The overall removal performance (%) of the pilot-scale set-up in view of different discharge parameters

Parameter	Influent concentration (mg/l)*	Removal performance (%) Organosorb 10 Removal	Airpel 10
Turbidity	20.8	90	37
Suspended solids	83.7	94	52
COD	202	87	66
NO_3^-	14	76	66

*Turbidity is expressed in FTU (formazin turbidity units).

Table 4 | Average festival wastewater characteristics before and after activated carbon treatment compared to local discharge limits

	TSS mg/l	COD mg O_2/l	Total N mg N/l	Total P mg P/l
Discharge limit	35	125	15	2
Untreated wastewater	83.7	202	9	1.3
Treated wastewater	5.33	23	8	1.6

The overall removal performance of the pilot-scale set-up in view of different discharge parameters (suspended solids, turbidity, nitrate, COD) is presented in Table 3. It can be seen that the performance of the activated carbon filter containing Organosorb is superior compared to the activated carbon filter containing Airpel, because of the breakthrough on day 3 and the fact that Organosorb is especially designed for water treatment.

Ammonium (influent concentration = 7 mgN/l) and phosphate (influent concentration = 4 mgN/l) were not removed by the activated carbon filter. With the activated carbon filter filled with Organosorb 90% COD removal was obtained and the discharge limits set by the local authority were met as presented in Table 4. As such the Dranouter Music Festival has decided to implement a full scale activated carbon filter for next year's (2008) event.

CONCLUSIONS

Activated carbon has proven to be a performant technique for the treatment of wastewaters originating from temporary events such as music festivals. This study characterised, designed and operated an activated carbon filter applied for the treatment of shower wastewater of the Dranouter Music Festival. Application of the activated carbon filter resulted in the fact that the local discharge limits were met without operational problems.

ACKNOWLEDGEMENTS

This study was supported by the Dranouter Music Festival, Desotec NV and the Institute for the Promotion of Innovation by Science and Technology in Flanders (IWT, contract number 060113).

REFERENCES

Amuda, O. S. & Ibrahim, A. O. 2006 Industrial wastewater treatment using natural material as adsorbent. *Afr. J. Biotechnol.* **5**(16), 1483–1487.

Chen, W. & Horan, N. 1998 The treatment of high strength pulp and paper mill effluent for wastewater re-use. Part III: tertiary treatment options for pulp and paper mill wastewater to achieve effluent recycle. *Environ. Technol.* **19**, 173–182.

Metcalf, & Eddy, Inc., Revised by Tchobananoglous, G. & Burton, F. L. 1991 *Wastewater Engineering: Treatment, Disposal and Reuse*. McGraw-Hill, McGraw-Hill series in water resources and environmental engineering, New York, USA.

Shawwa, A. R., Smith, D. W. & Sego, D. C. 2000 Color and chlorinated organics removal from pulp mills wastewater using activated petroleum coke. *Water Res.* **35**, 745–749.

Standard Methods 1992 *Standard Methods for the Examination of Water and Wastewater* (18th edition) American Public Health Association (APHA), Inc. New York.

Thomas, W. J. & Crittenden, B. 1998 *Adsorption Technology and Design*. Butterworth-Heinemann, Oxford, UK, pp. 288.