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Sewer odour control: practical assessment of gas phase treatment systems

A. Pérez[1], JL. Cortina[1], B. Barillon[2], M. Martaud[3], A. Llopart-Mascaró[4], J. Feliu[5], L. Bouchy[1]
[1]CETaqua, Centro Tecnológico del Agua
Paseo de los Tilos, 3. 08034 Barcelona, Spain
[2]Suez Environnement – CIRSEE. 38 rue du Président Wilson, 78230 Le Pecq, France
[3]CTA. 51 Avenue de Sénart, BP29, 91230 Montgeron, France
[4]CLABSA. Acer 16, 3ª planta, 08038 Barcelona, Spain
[5]EMUASA. Plaza Circular 9, 30008 Murcia, Spain

The decrease in drinking water consumption, climate change, the evolution of odour regulations and the increased social pressure on olfactory comfort are changes that, nowadays, are leading to increase odour and H_2S production in sewer networks, as well as odour nuisance. This work presents a study carried out in order to perform an assessment of sewer odour and H_2S treatment systems, more specifically focused on gas phase treatment technologies. The assessment has been based on the integration of published experience at research level, technical data from technology suppliers and field audits, which allowed to establish a mapping of application field treatments.

1. Introduction

Odours and H_2S nuisance in sewers is not a new problem, and many works have been carried out on this topic in the last three decades (Musquere et al., 1983; Boon, 1995; Zhang et al., 2008). In terms of odours, residents are more and more demanding, and general odour regulations are more and more aimed at guaranteeing the olfactory comfort of the population. Within this context, sewers are a critical point of odours in some cities. The decrease in drinking water consumption can involve reduction of linear velocity in pipes, longer retention times and higher pollutants concentrations, promoting an increase of odours. For all these reasons, it is necessary to know the causes of sewer odour problems and how to avoid them. Odours associated to sewer networks can be removed using different treatment systems, including in-pipe treatments (using dosing of reagents as ferric chloride, nitrates, air, oxygen, etc.) and air treatments (using ventilation and treatment via biofiltration, adsorption, etc.) (Zhang et al., 2008). This paper is focused on the technical assessment of the efficiency of gas-phase treatments.

2. Methodology

In order to be able to take into account both established and developing technologies, and to compile both scientific and operational data, this study was carried out by using

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three different information sources: research data, contacts with treatment technologies providers, and audits from industrial plants (“field audits”). The gas phase treatment systems, and the technologies selected were biological, physical and chemical treatments, masking agents and ventilation systems. Finally, different criteria were considered to benchmark the technologies: economic, technical and environmental.
Several sites were visited for the field audits, mainly across Europe and also in North America (USA), as it is shown on Figure 1. These audits were carried out on Suez Environnement sites. Figure 1 describes also the technologies used in each site. The literature research and the discussions with treatment suppliers were used to interpret the results of the field audits and give recommendations on the implementation and optimal operation of each treatment system.

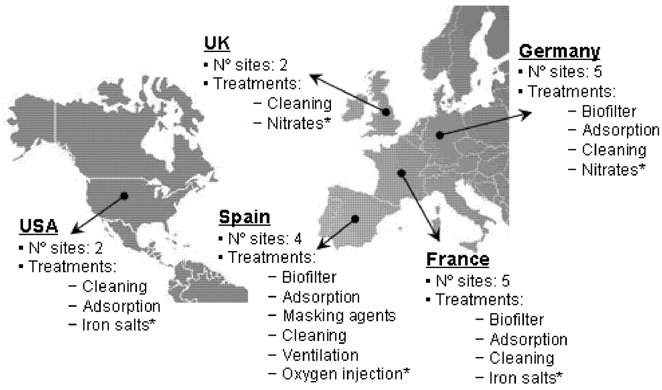


Figure 1. Details of the sites used for audits of industrial plants (location and technologies and treatments used).

3. Results and discussion

3.1 Overview of general practices

The field audits in the different locations selected allowed to assess a wide variety of scenarios, in terms of climate, regulatory and social context and sewer management culture. These audits have shown that the use of each treatment is site specific: often within a given area in the same country, only one type of treatment is implemented, on which the operators have gained much experience. As a primary approach, Table 1 provides a summary of the main treatments used in the different countries evaluated.

Table 1 Main treatments in different sites

SITE	MAIN TREATMENTS
France	Chemical (iron salts)
Germany	Biological (biofiltration), Physical (adsorption)
Spain	Physical (adsorption), Biological (biofiltration)
UK	Chemical (nitrates)
USA	Physical (adsorption)

As it is reflected in Table 1, in France and the UK, the most common treatments are in-pipe treatments: iron salts are injected at the inlet of forced mains, whereas nitrates are more frequently injected directly in wet wells. In Spain, Germany and USA, mainly gas phase treatments are applied, and biofiltration and adsorption technologies are used. It is important to note also that all the sites visited are using mainly conventional treatments.

3.2 Consumptions

Each treatment has specific consumptions, according to its requirements. For example, biofilters, adsorption systems and scrubbers usually must be located on sites with an available energy source (Stuetz and Frechen, 2001). Figure 2 shows a comparison between the main consumptions on different gas-phase odour treatments. Values are normalized in a scale moving from 0, the lower consumption, to 1 the higher one.

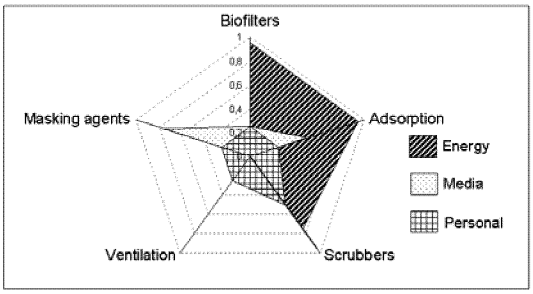


Figure 2. Comparison of operation requirements on gas-phase odour treatments evaluated. Values are normalized to a relative scale.

The main type of consumption for air treatments is the energy consumption, as these treatments consist in "capture and treat" the odours present in the gas phase, using blowers. In that case, biofilters and adsorption systems have higher energy consumptions than scrubbers, being 0 in the case of ventilation and masking agents. However, scrubbers have a high consumption of chemical products that increase the requirements on security. This is one of the reasons for which scrubbers are not recommended for odour treatment on sewers. Masking agents can be implemented in different ways (Bruchet et al., 2008), the most commonly implemented on the sewers audited was the use of plates. In this case, the actual plates of masking agents are the main consumable. Regarding adsorption systems, the media is an important consumable. There are different types of adsorbents, and the material selection depends on the odour compounds to be removed and the removal efficiency required. The most important adsorbent and the most used is granular activated carbon. Activated carbons used are unmodified activated carbons, impregnated activated carbons or catalytic activated carbons.Alumina, silica and zeolitas are other adsorbents that can be also used.

3.3 Evaluation of costs

The study of treatment costs was a difficult task, as scarce information is available in the literature and the data are usually not properly separated or monitored on the different industrial sites audited. There are several factors that must be taken into account to estimate the investment costs (CAPEX), for example: the size of the system and its configuration. To evaluate the operation costs (OPEX), different consumptions have been taking into account: energy, reagents, personal, water, etc. A global comparison of CAPEX and OPEX for each treatment is shown on Figure 3a. Scrubbers are the most expensive treatments in both terms (investment and operation). Masking agents have low costs, whereas ventilation requires a high investment (depending on the number of chimneys necessary) but has lower operation costs. Figure 3b illustrates a comparison between the more common gas-phase treatments in sewers (adsorption and biofiltration), in terms of operation costs. It is important to point at the high influence on the type of adsorbent. Adsorption via impregnated AC is between twice and three times the operation cost of biofiltration whatever the size. However both technologies allow for drastic OPEX reductions at higher system sizes.

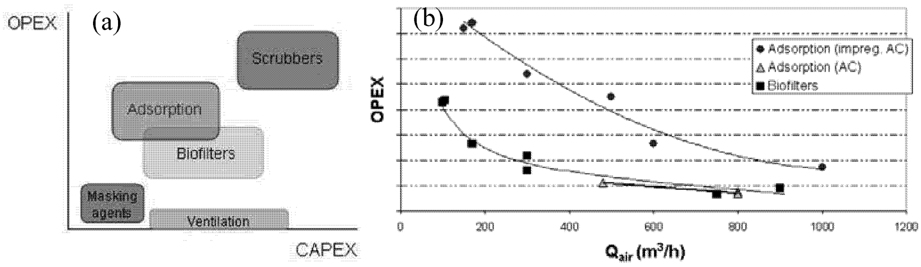


Figure 3. (a) General comparison CAPEX-OPEX between different air treatments. (b) OPEX comparison between adsorption (using activated carbon, AC, or impregnated activated carbon) and biofilters.

3.4 Impact on the environment

Treatments in the gas phase do not affect the effluent (unless stripping is carried out, which improves its quality reducing its downstream H_2S emission potential). The main direct impacts on the environment are therefore the waste by products generated by the treatment systems. Biofilters have a low impact, as the wastewater generated is assimilated to urban wastewater and can be directly discharged in the sewer. Adsorption perhaps has the most important impact in this case, as the saturated adsorbent is a waste and must be treated as such (usually requiring to be sent to a waste manager).

3.5 Guide for technology selection

There are many options for odour treatment in sewers (Boon, 1995; Zhang et al., 2008). However, it is possible to establish a mapping of the most adequate application field depending on the location in the network. Each treatment is used in a specific part of the sewer according to its conditions and requirements on the sewer system. Figure 4 shows the preferred location of each type of treatment considered, based on consumables, removal efficiency, simplicity of implementation, surface required, environmental impact, costs (CAPEX and OPEX) and the maintenance and security requirements. Cleaning is an important treatment in all sites to reduce the amount of solids present in the sewer and to avoid the septicity of the wastewater. For pumping stations, adsorption (Bandosz et al. 2000; Xiao et al., 2008) and biological systems (Moosavi et al. 2005) stand out as the most usual treatments for treating the odours generated in the wells.

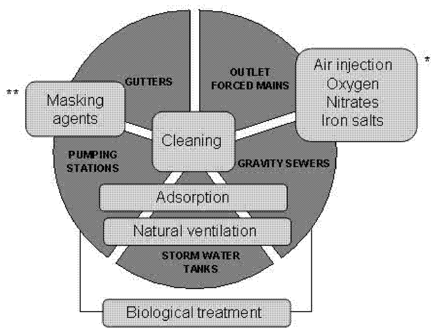
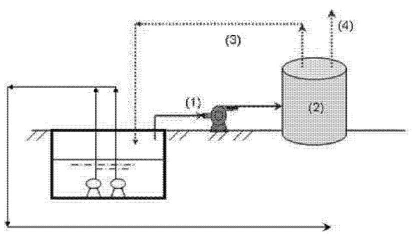


*Figure 4. Adapted treatments for each type of location of odour. * In-pipe treatments. ** Should be placed in the environment or in chimneys.*

There are different biological treatments: biofilters, biotrickling filters and bioscrubbers (Syed et al., 2006), however, the most used in sewers are biofilters. Biotrickling filters and bioscrubbers are more frequently used in wastewater and sludge treatment plants. Figure 5 shows the most common configuration for biofilters and adsorption systems, where (1) indicates the blower, (2) the treatment tower, (3) the return of the exhaust air to the well and (4) the off take of the exhaust air to the environment. In some cases these treatments do not require a blower: the own increase of the water level in the reservoir expels the exhaust air to outside and, before the air arrives to the atmosphere, it is treated by the filter. This configuration is not very common, and its efficiency need to be better assessed, but makes much sense in terms of low energy implementation.



(1) Blower
(2) Treatment tower
(3) Return of the exhaust air to the well
(4) Off take of exhaust air to the environment

Figure 5. Common configuration for air treatments that "capture and treat" the odour in the gas phase of a well.

4. Conclusions

Although all the treatments reviewed are technologies to treat odours in the sewers, each treatment is more adapted to certain configurations, and thus to specific parts of the sewer. It was therefore possible to establish a mapping of application field. In pumping stations, the treatments used are mainly biological and adsorption systems; in forced mains, the technologies most commonly used are applied in the effluent; in gravity sewers, the most adequate technology seems to be ventilation, however the knowledge of this treatment is very poor and to this date there is no control over it; in storm water tanks the most common treatment used is the adsorption with activated carbon, because in storm water tanks the concentration of pollutants is not constant, so biofilters are not recommended in that case. Other treatments as masking agents can be used to complement the previous. Although scrubbers are a technology commonly used in other odour contexts (as wastewater or sludge treatment plants), they are not a recommended technology in sewer systems due to their high level of maintenance and operation, and their high costs. Regarding consumables, energy accounts for the main part for gas treatments. It is possible to use configurations which do not require blowers. However, their efficiency must be assessed, especially in terms of configuration and aerodynamics control. In terms of cost comparison, masking agents are the cheapest treatments. For this reason and also for their easy implementation, they are used in some sites to avoid nuisances and residents complaints in punctual areas. However, it is important to know that these treatments do not remove pollutants, they only avoid nuisance. They "mask odours" and can be dangerous in confined spaces. Ventilation is a treatment that requires high investment costs, but its operation costs are very low. Adsorption and biofilters are treatments very similar in terms of costs. The main differences belong to the media used for the treatment. The selection must be made according to the removal requirements and the odorous compounds present in each case.

Acknowledgements
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