

# HYBRID MEDIA SELECTION FOR EXTENDING ACTIVATED CARBON BED LIFE IN ODOUR CONTROL UNITS

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## Abstract

Impregnated activated carbon remains the most robust base media for wastewater odour control units (OCUs) because it provides broad-spectrum removal of hydrogen sulphide (H<sub>2</sub>S), volatile organic compounds (VOCs) and other odorous compounds. However, field performance is often limited by the contaminant that breaks through first. Where H<sub>2</sub>S consistently drives breakthrough, an upstream iron hydroxide layer can perform the bulk H<sub>2</sub>S duty and preserve the impregnated carbon as a polishing layer. Where VOC breakthrough is the limiting issue, VOC-specific or virgin activated carbon can be used with impregnated carbon. Where monitoring confirms that the gas stream contains only H<sub>2</sub>S and VOCs, and broader sulphur species are not a design concern, iron hydroxide followed by virgin or VOC selective carbon may be appropriate. This paper presents a practical, breakthrough-led media selection framework aligned with Australian OCU design practice based on learnings and experience obtained in European OCUs. It discusses H<sub>2</sub>S reaction chemistry, accelerated breakthrough testing based on ASTM D6646-03, humidity impacts, cost per kilogram of sulphur removed and spent-media handling. Iron hydroxide is typically lower cost than impregnated carbon and, because it is selective for H<sub>2</sub>S, can reduce the cost per kilogram of sulphur removed by approximately 40–50% in suitable applications. It also typically provides approximately 50% longer H<sub>2</sub>S bed life than impregnated activated carbon under comparable H<sub>2</sub>S duty, reducing change-out frequency. The pressure drop through the iron hydroxide was similar to that of activated carbons and was therefore not an impact on CAPEX or OPEX. The proposed framework does not replace impregnated activated carbon as the conservative base design; it uses targeted media only when site monitoring demonstrates a repeatable breakthrough mechanism.

**Keywords:** odour control, activated carbon, hydrogen sulphide, iron hydroxide

## 1. Introduction

Sydney Water is a technical leader in Australian OCU design and operation, having developed a comprehensive OCU standard, published extensively on OCU innovation and developed in-house H<sub>2</sub>S breakthrough testing capabilities. Due to the breadth of publicly available information, this paper uses Sydney Water as a representative framework for OCU design and operation across Australia.

Activated carbon adsorption is one of the most common technologies used for wastewater odour control because it is compact, reliable and capable of treating mixed odorous air streams. In Australian wastewater network applications, impregnated activated carbon is commonly adopted as the base media because it combines physical adsorption with chemically enhanced removal of H<sub>2</sub>S and other odorous gases. Sydney Water's OCU specification recognises activated carbon OCUs and includes requirements for media bed life, sampling, monitoring, pre-treatment and humidity management (Sydney Water Corporation 2025).

The central argument of this paper is deliberately conservative: impregnated activated carbon should remain the default media for most OCUs. It is a broad-spectrum and familiar technology, and it provides an important risk-control function where gas composition is variable or incompletely characterised. However, OCU bed life is often

determined by the contaminant that breaks through first. If that contaminant is repeatedly H<sub>2</sub>S, then a bed consisting only of impregnated carbon may be using a comparatively high-value broad-spectrum media for bulk H<sub>2</sub>S removal. If VOCs repeatedly break through, then a carbon selected mainly for H<sub>2</sub>S duty may not provide the best VOC adsorption performance.

A more efficient approach is therefore to start with impregnated activated carbon as the base design, then add targeted media only where site monitoring demonstrates a consistent failure mode. The framework proposed is breakthrough-led rather than product-led. In Europe, this approach has been applied in a large number of OCU installations and has demonstrated practical performance improvements where media selection is aligned with the dominant breakthrough mechanism.

The increasing availability of compact, high-resolution gas monitoring technologies further strengthens this approach, enabling improved visibility of OCU performance and facilitating data-driven media optimisation in operating systems (wired and 4G enabled sensors for H<sub>2</sub>S, VOCs and NH<sub>3</sub>).

## 2. Base design philosophy

The proposed design philosophy is: use impregnated activated carbon as the base design, then supplement it only when reliable operating data shows that H<sub>2</sub>S or VOC breakthrough consistently

limits bed life. This avoids unnecessary specialisation at sites where a robust general-purpose bed is appropriate, while allowing targeted improvements where the operational evidence is clear. Where there are multiple sites that have a very strong correlation in the odorant species, and operational parameters (flow, temperature, humidity etc) then the information from one site can be extrapolated to others.

Table 1. Breakthrough-led media selection framework.

| Site condition                                                               | Recommended media strategy                                                           |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Mixed or uncertain odour profile                                             | Impregnated activated carbon as the base design.                                     |
| H <sub>2</sub> S breakthrough consistently occurs first                      | Iron hydroxide primary layer followed by impregnated activated carbon.               |
| VOC breakthrough consistently occurs first                                   | Impregnated activated carbon with VOC-specific or virgin activated carbon.           |
| Only H <sub>2</sub> S and VOCs confirmed; no other odorous sulphur compounds | Iron hydroxide followed by virgin or VOC activated carbon.                           |
| Poor humidity control or operation near 100% RH                              | Consider iron hydroxide as primary H <sub>2</sub> S layer before impregnated carbon. |

### 3. Why impregnated carbon remains the default

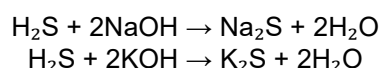
Impregnated activated carbon is the appropriate starting point for most OCUs because it provides the widest practical treatment envelope. It can remove H<sub>2</sub>S through chemical reaction and catalytic oxidation, while still retaining physical adsorption capacity for a range of odorous organic compounds. It also aligns with industry familiarity, OCU supplier practice and utility risk expectations.

This is particularly important where the odour profile is mixed, variable or uncertain. Under these conditions, removing impregnated activated carbon entirely may reduce operational resilience. For that reason, even when iron hydroxide is used for bulk H<sub>2</sub>S removal, a downstream impregnated carbon layer is normally recommended as a conservative polishing stage unless monitoring confirms that only H<sub>2</sub>S and VOCs are present and broader sulphur species are not material.

## 4. Chemistry of H<sub>2</sub>S removal

### 4.1. Caustic impregnated activated carbon

Caustic impregnated carbons typically contain sodium hydroxide or potassium hydroxide. H<sub>2</sub>S is neutralised to form hydrosulphide species, with simplified reactions shown below:

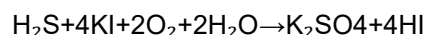


In the presence of oxygen, sulphide species may be further oxidised to elemental sulphur, sulphite or

sulphate. Caustic impregnation gives rapid H<sub>2</sub>S removal but can be sensitive to moisture migration, caking and redistribution of impregnant if condensation occurs.

### 4.2. Potassium iodide impregnated activated carbon

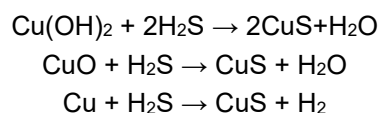
Potassium iodide impregnated carbon promotes catalytic oxidation of H<sub>2</sub>S. A simplified overall reaction is:



The carbon provides the surface and pore structure, while iodide promotes oxidation. This media type maintains activated carbon's broad-spectrum adsorption characteristics while improving H<sub>2</sub>S performance.

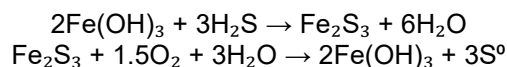
### 4.3. Copper oxide impregnated activated carbon

Copper oxide impregnated carbon removes H<sub>2</sub>S through reaction with metal oxide sites and subsequent oxidation pathways. A simplified reaction is:



### 4.4. Iron hydroxide media

Iron hydroxide removes H<sub>2</sub>S by reaction with ferric hydroxide surfaces to form iron sulphide and elemental sulphur species. In oxygen-containing gas streams, regeneration occurs as sulphide is oxidised and iron hydroxide sites are restored. The elemental sulphur builds up on the surface of the media this will lead, to the media becoming unreactive and requiring changeout. A simplified sequence is:



This pathway explains why iron hydroxide is highly selective for H<sub>2</sub>S and why it can be used to protect impregnated carbon from bulk H<sub>2</sub>S loading.

## 5. Media performance testing and bed life

Hydrogen sulphide breakthrough capacity for activated carbon is commonly assessed using ASTM D6646-03, 2003, Standard Test Method for Determination of Accelerated Hydrogen Sulfide Breakthrough Capacity of Granular and Pelletized Activated Carbon. Sydney Water's OCU standard references ASTM D6646 for H<sub>2</sub>S breakthrough capacity testing of activated carbon and specifies minimum design expectations including carbon/filter

design life and contact time (Sydney Water Corporation 2025; ASTM International 2003).

The laboratory test arrangement in Figure 1 is similar to ASTM D6646 accelerated breakthrough testing because it uses controlled gas flows, defined  $H_2S$  concentration, oxygen, relative humidity, contact time and parallel reactors. Such tests are useful for comparing media under repeatable conditions, although field bed life must also consider inlet variability, humidity, pressure drop, media depth and maintenance practices. These tests were performed based on conditions more similar in biogas processing, as opposed to trying to align specifically with ASTM D6646.

A table comparison of the Figure 1 tests and ASTM D6646 has been provided.

| Table 2. Figure 1,2,3,4 test condition comparison to ASTM D6646-03, 2022. |     | Test Conditions | ASTM D6646-03, 2022 |
|---------------------------------------------------------------------------|-----|-----------------|---------------------|
| Relative humidity                                                         | %   | 50              | 80                  |
| $H_2S$ -concentration                                                     | ppm | 4,512           | 10,000              |
| Threshold for removal rate                                                | %   | 98              | 99.5                |
| $O_2$ -concentration                                                      | ppm | 19,000          | 163,000             |
| Contact time                                                              | s   | 4.75            | 4.8                 |



Figure 1. Laboratory gas mixing and parallel reactor arrangement used for comparative  $H_2S$  breakthrough testing; similar to ASTM D6646 accelerated breakthrough testing (Courtesy of Hego Biotec International GmbH).

For  $H_2S$  removal duty, iron hydroxide typically provides approximately 50% longer bed life than impregnated activated carbon under comparable  $H_2S$  loading. This can reduce the time between media change-outs and lower maintenance impacts. The advantage should be assessed on a volume and

duty basis, not simply on media mass, because media density affects the amount of reactive material that can be installed in a fixed OCU vessel.

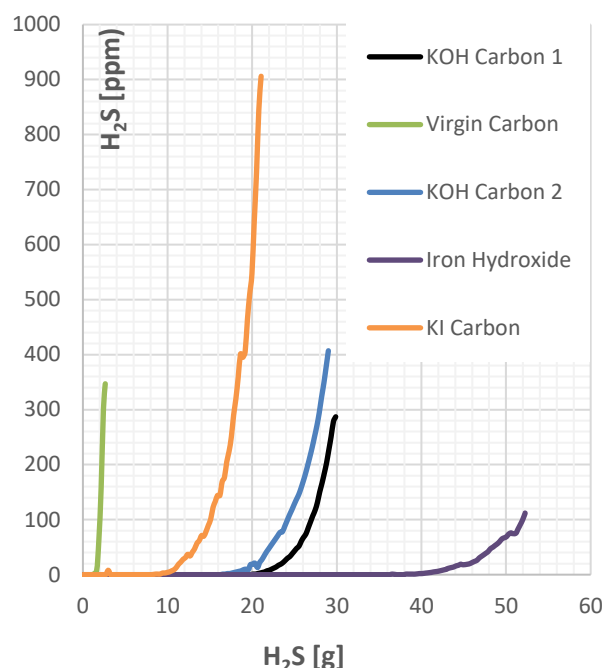


Figure 2. Example accelerated  $H_2S$  breakthrough curves under controlled laboratory conditions.

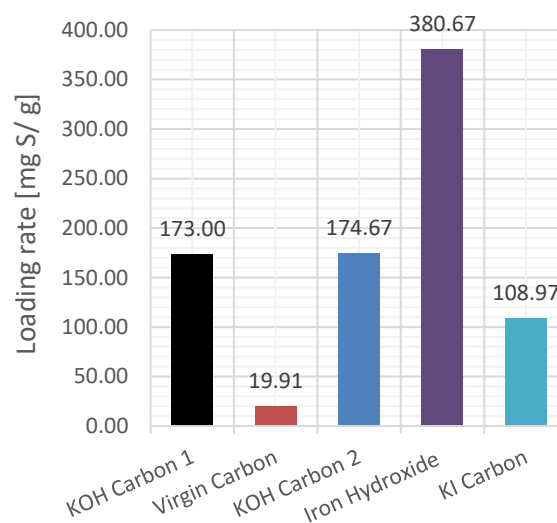


Figure 3. Example mass-based loading comparison for gas purification media.

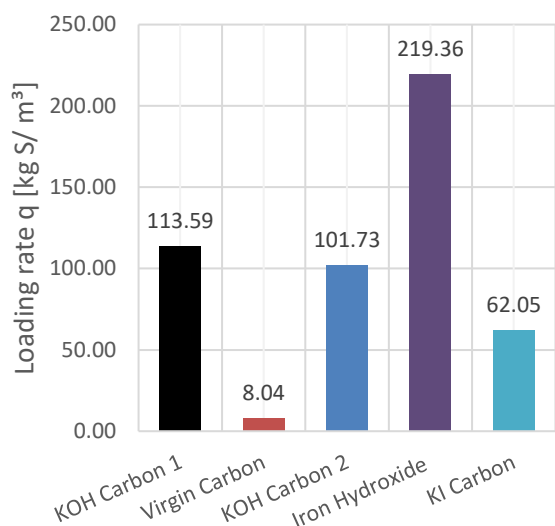


Figure 4. Example volume-based loading comparison, illustrating the importance of density when comparing fixed-bed media.

One additional test was then completed which is more closely aligned with the ASTM D6646-03 conditions. Iron hydroxide media was tested against a copper impregnated coal-based carbon commonly available in the Australian market.

Table 3. Figure 5,6,7 test condition comparison to ASTM D6646-03, 2022.

|                                |     | Test Conditions | ASTM D6646-03, 2022 |
|--------------------------------|-----|-----------------|---------------------|
| Relative humidity              | %   | 72              | 80                  |
| H <sub>2</sub> S-concentration | ppm | 10,000          | 10,000              |
| Threshold for removal rate     | %   | 99.5            | 99.5                |
| O <sub>2</sub> -concentration  | ppm | 163,000         | 163,000             |
| Contact time                   | s   | 4.68            | 4.8                 |

Figure 5. Example accelerated H<sub>2</sub>S breakthrough curves under controlled laboratory conditions, iron hydroxide media and copper impregnated coal-based carbon

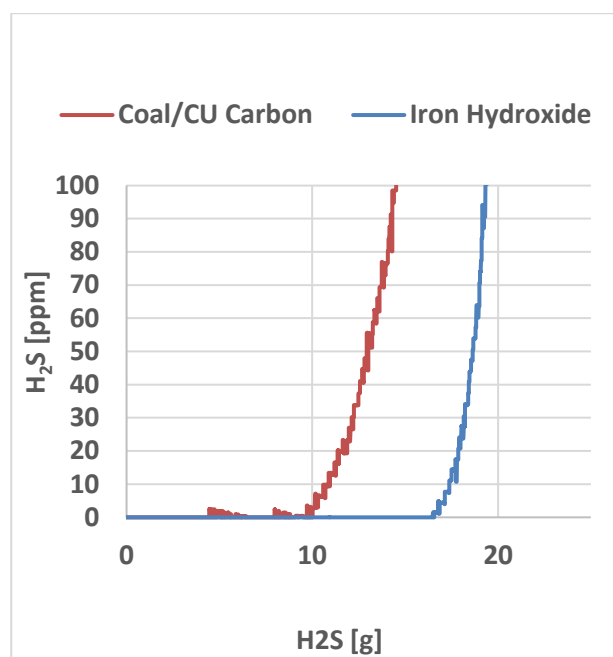


Figure 6. Mass based loading of iron hydroxide media and a copper impregnated coal-based carbon commonly available in the Australian market. The iron hydroxide based media shows a 28% greater loading.

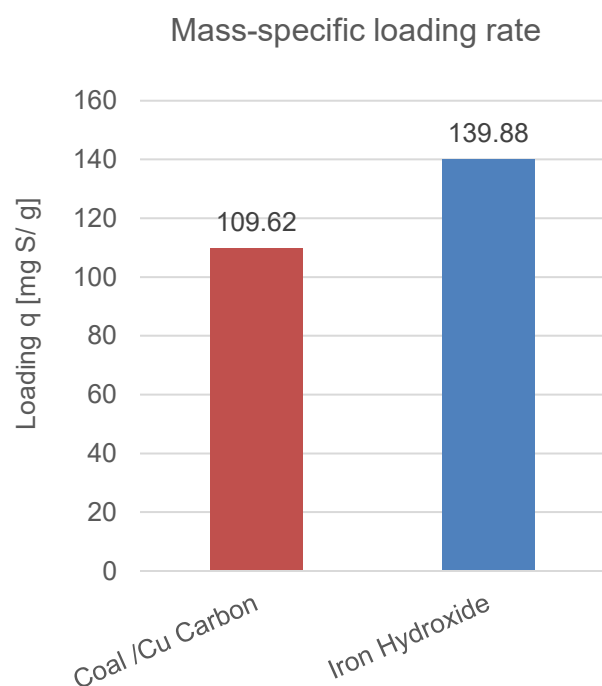
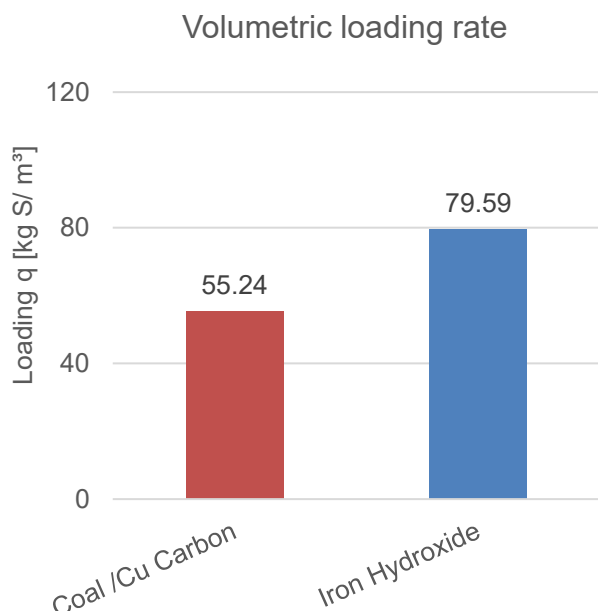


Figure 7. Volume based loading of iron hydroxide media and a copper impregnated coal-based carbon commonly available in the Australian market. The iron hydroxide-based media shows a 44% greater loading. Indicating significantly longer bed life is achievable.



## 6. Cost per kilogram of sulphur removed

OCU economics should consider cost per kilogram of sulphur removed rather than purchase price alone. Iron hydroxide media is typically lower cost than impregnated activated carbon and is more selective for  $\text{H}_2\text{S}$ . In suitable high- $\text{H}_2\text{S}$  applications, this can reduce the cost per kilogram of sulphur removed by approximately 40–50%. The benefit is greatest where  $\text{H}_2\text{S}$  breakthrough is the recurring replacement trigger and where impregnated carbon is otherwise being consumed primarily for bulk  $\text{H}_2\text{S}$  duty. The magnitude of cost savings will depend on site-specific factors including media supply cost, installed bulk density, achievable sulphur loading, disposal costs and change-out frequency. Therefore, evaluation should be undertaken on a lifecycle cost basis rather than media purchase cost alone.

Using the values from Figures 5,6,7 and some typical market retail prices for the products, the following indications of economics can be deduced.

Copper impregnated coal-based carbon commonly available in the Australian market retails at around 50% more than iron hydroxide media. The mass-based loading for the iron hydroxide media was 28% higher (Figure 6), when combining these two factors,

using iron hydroxide media would reduce the expenditure on media by 48%.

There is a significant cost associated with the change out of media, based on Figure 7, the bed life would be 44% longer. This would mean that for a given bed size, the media change out could events over the life of the bed would reduce by 30%. The reduced bed change out events has a two fold costs, a reduction in the operational costs associated with the change out; and since odour complaints are most common close to time when the media is changed, a potential for a 30% reduction in odour complaints.

The practical design outcome is to place the lower-cost,  $\text{H}_2\text{S}$ -selective media upstream, allowing impregnated activated carbon to perform its higher-value role as a polishing and broad-spectrum risk-control layer. This can extend the effective life of the overall bed and reduce the frequency of change-outs.

## 7. Humidity and preheating

Humidity is a critical operating parameter for activated carbon OCUs and is particularly important where impregnated activated carbon is expected to provide reliable  $\text{H}_2\text{S}$  and VOC removal. Although moisture is required to support  $\text{H}_2\text{S}$  oxidation reactions on activated carbon, excessive moisture becomes detrimental. The activated carbon literature indicates that  $\text{H}_2\text{S}$  adsorption can improve under humid conditions compared with dry gas; however,  $\text{H}_2\text{S}$  capacity may decrease as relative humidity increases from 50% to 80%, with an optimum for basic or catalysed carbons reported at approximately 60% RH. Above this range, condensed water can occupy micropores, restrict contact between  $\text{H}_2\text{S}/\text{HS}^-$  species and the carbon surface, and promote the formation of sulphuric acid, which can suppress further  $\text{H}_2\text{S}$  dissociation and reduce ongoing adsorption performance (Le-Minh, Sivret & Stuetz 2014).

In practice, many existing OCUs do not have a functioning preheater or equivalent humidity-control system, and therefore operate continuously at or near 100% relative humidity. This is unfavourable for impregnated activated carbon, as water can block pore access, reduce VOC adsorption capacity, broaden breakthrough curves, and contribute to premature breakthrough. The literature notes that relative humidity above 50–60% can severely affect VOC adsorption on activated carbon, and that in Australia it is common for sewer air entering activated carbon adsorbers to remain above 80% RH, potentially reducing removal effectiveness due to sub-optimal operating conditions (Le-Minh, Sivret & Stuetz 2014). Sydney Water's OCU standard also recognises this issue by requiring humidity management upstream of activated carbon beds, including in-line duct heating

to reduce relative humidity before the adsorber (Sydney Water Corporation 2025).

By contrast, iron hydroxide media can operate effectively at 100% relative humidity for H<sub>2</sub>S removal. This makes it particularly well suited as a primary H<sub>2</sub>S removal layer in OCUs where humidity control is absent, unreliable or impractical. In these applications, iron hydroxide can remove the bulk H<sub>2</sub>S load under saturated conditions, while the downstream impregnated activated carbon is retained as a polishing layer and is protected from performing bulk H<sub>2</sub>S removal under unfavourable high-humidity conditions. Where VOC breakthrough is the limiting issue, humidity management remains important because VOC adsorption on carbon is generally less effective at high relative humidity; therefore, VOC carbon should be used with appropriate demisting, drainage and heating where practicable.

## 8. Application cases

### 8.1. H<sub>2</sub>S breakthrough-limited sites

If monitoring shows that outlet H<sub>2</sub>S exceeds the target before the expected bed life is reached, the recommended configuration is iron hydroxide followed by impregnated activated carbon. The iron hydroxide performs bulk H<sub>2</sub>S removal and the impregnated carbon provides residual H<sub>2</sub>S polishing and broader odour control. This is the preferred hybrid arrangement for high-H<sub>2</sub>S sites.

### 8.2. VOC breakthrough-limited sites

If H<sub>2</sub>S remains controlled but VOCs or odour complaints persist, the limiting mechanism is likely VOC adsorption capacity, or other sulphur compounds rather than H<sub>2</sub>S reaction capacity. The recommended configuration is impregnated activated carbon with VOC-specific or virgin activated carbon. The VOC layer can provide polishing capacity selected for pore structure and physical adsorption of organics. The order of the layers would be site specific as it depends if the VOC constituents at the site would or would not impact the impregnated carbon.

### 8.3. Sites with only H<sub>2</sub>S and VOCs

If monitoring confirms that the gas stream contains only H<sub>2</sub>S and VOCs, with no material contribution from other odorous sulphur compounds, a more specialised arrangement may be used: iron hydroxide followed by virgin or VOC-specific activated carbon. This configuration separates the two dominant removal mechanisms. Iron hydroxide provides selective bulk H<sub>2</sub>S removal, while the downstream virgin or VOC-specific carbon is reserved for physical adsorption of VOCs. This is important because VOC removal on activated carbon is predominantly governed by physisorption, and the literature indicates that physical adsorption

is maximised in virgin activated carbon where more adsorption sites remain available for the target VOCs. By contrast, chemical impregnation can reduce the surface area and pore volume available for physical adsorption, potentially reducing capacity for non-target compounds such as VOCs (Le-Minh, Sivret & Stuetz 2014). Virgin carbon, particularly carbon with an appropriate micropore structure such as coconut-shell-based carbon, can therefore be better suited to VOC polishing than impregnated carbon where H<sub>2</sub>S has already been removed upstream. This option should still be applied cautiously and should include periodic validation of the odour profile. If the gas profile is uncertain, variable, or includes other odorous sulphur compounds, impregnated activated carbon should remain in the system as the conservative broad-spectrum polishing layer. Figure 8 is a typical passive OCU unit utilised in Germany.



Figure 8: OCU in Germany with Iron Hydroxide 1<sup>st</sup> stage and activated carbon to remove VOCs 2<sup>nd</sup> stage, flow 370 m<sup>3</sup>/h, H<sub>2</sub>S 350 ppm, humidity 90 – 100 %

## 9. Spent media handling and disposal

Spent media handling is a lifecycle consideration. Impregnated activated carbon can adsorb H<sub>2</sub>S, VOCs, siloxanes and other compounds, which is beneficial during operation but can complicate disposal because the spent media may contain a mixed contaminant profile. The impregnates themselves can also provide challenges with regards to disposal. Iron hydroxide is more selective for H<sub>2</sub>S and generally takes up far lower levels of VOCs and siloxanes than activated carbon, the H<sub>2</sub>S is converted to elemental sulphur as opposed to compounds with other chemicals.

To assess the extent of non-target contaminant accumulation and its potential impact on end-of-life handling, analyses were undertaken on spent media recovered from a wastewater treatment plant installation. The objective was not to assess odour removal performance, but rather to understand the degree to which VOCs and siloxanes are retained within each media type and the implications this may have for waste classification and disposal options.

A comparative technical note on a wastewater treatment plant installation reported total VOC loading of 16.24 mg/kg on iron hydroxide media, compared with 16,045.52 mg/kg and 5,143.65 mg/kg on two downstream activated carbon filters. D4 siloxane loading was reported as 0.16 mg/kg on iron hydroxide, compared with 950 mg/kg and 600 mg/kg on the activated carbon filters (Bharti n.d.).

Iron hydroxide is not classified as a chemical in its supplied state in the same way as chemically impregnated carbon, and because it takes up relatively little non-H<sub>2</sub>S impurity, spent media may be easier to landfill subject to local waste classification and contaminant testing. In some international applications, spent iron hydroxide media has been blended with biosolids for beneficial reuse as a soil or fertiliser amendment, where permitted by local regulation.

## 10. Monitoring and validation

A breakthrough-led media strategy requires reliable monitoring and periodic validation of the actual odour profile leaving the bed. At a minimum, OCUs should include inlet and outlet H<sub>2</sub>S monitoring, differential pressure monitoring, and manual sampling points upstream and downstream of the media bed. These measurements provide the basic information required to identify changes in inlet loading, confirm pressure-drop development, and determine whether breakthrough is occurring before the expected media life is achieved. For smaller units where this cost cannot be justified, chemical based hydrogen sulphide breakthrough indicators can be installed (commonly referred to as colorimetric indicator) that indicates the saturation in or after the adsorbent beds.

In practice, continuous online monitoring is generally limited to H<sub>2</sub>S. It is often not practical or cost-effective to install online analysers for VOCs or non-

H<sub>2</sub>S sulphur compounds at every OCU. Therefore, to properly implement a breakthrough-led strategy, manual outlet testing should be undertaken prior to each scheduled media change-out, or earlier if odour complaints, abnormal outlet H<sub>2</sub>S readings, or reduced bed life indicate possible breakthrough. This testing should include H<sub>2</sub>S, VOCs and, where relevant, non-H<sub>2</sub>S sulphur compounds.

The purpose of this testing is to identify which odorous species are making the largest contribution to the outlet odour profile at the end of the media life. This information then becomes a key design input for the next media selection review. For example, if H<sub>2</sub>S is the dominant breakthrough compound, an upstream iron hydroxide layer may be justified to protect the impregnated activated carbon. If VOCs dominate the outlet odour profile while H<sub>2</sub>S remains controlled, the inclusion of a virgin or VOC-specific carbon layer may be more appropriate. If the outlet profile is mixed, uncertain or dominated by non H<sub>2</sub>S sulphur compounds, impregnated activated carbon should remain the conservative majority media.

This monitoring approach ensures that media selection is based on measured site performance rather than assumed gas composition. Over successive media cycles, the results can be used to refine the media configuration, optimise layer depths, improve bed-life predictions and reduce unnecessary media replacement. Where sites share similar odorous component profiles and operating conditions, the learnings can be shared across multiple sites.

Recent advancements in compact gas monitoring systems further support the implementation of a breakthrough-led media strategy. Recent advances in electrochemical sensing technology have reduced the capital and operating costs associated with sensors that can measure H<sub>2</sub>S at ppm levels upstream of the bed and at ppb levels at the outlet, along with other sensors capable in monitoring VOCs, ammonia (NH<sub>3</sub>) and differential pressure. These systems can be deployed as permanently wired instrumentation or as temporary battery-powered units with remote communication (e.g. 4G).

The availability of this technology enables real-time or near real-time assessment of OCU performance, allowing operators to more accurately identify breakthrough conditions and understand the relative contribution of different contaminant groups. It also facilitates comparative field trials of different media configurations under real operating conditions. This capability significantly enhances the practical application of hybrid media strategies, allowing design decisions to be based on measured performance rather than inferred behaviour. Figure 9 below depicts the instrument configuration for a single bed system that could be employed for hybrid media applications.

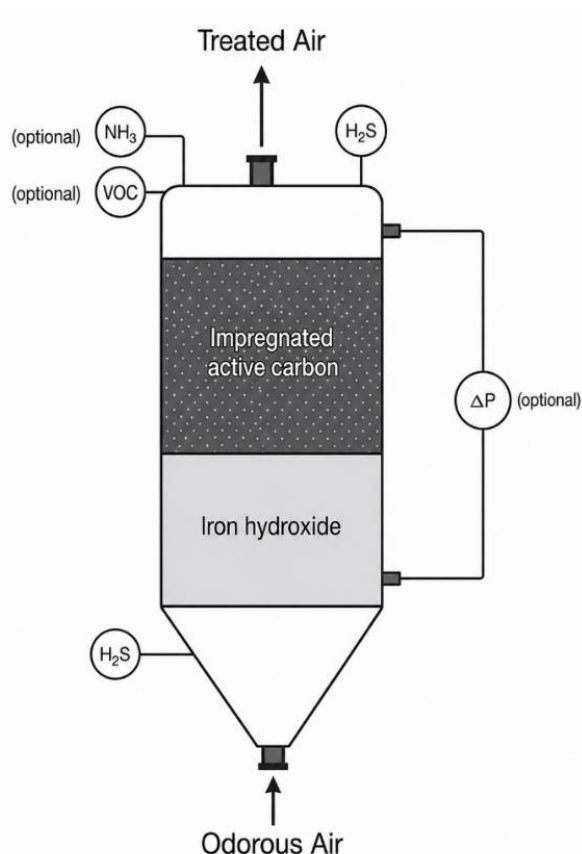


Figure 9: Ideal instrumentation layout for either field trials or permanent operation.

## 11. Conclusions

This paper has presented a breakthrough-led framework for media selection in wastewater odour control units, where media selection is based on observed performance and contaminant breakthrough rather than relying on a single media solution for all applications. The findings support retaining impregnated activated carbon as the default and most broadly applicable media for wastewater odour control. However, where operating data demonstrates that  $H_2S$  or VOC breakthrough is consistently limiting bed life, targeted media can be incorporated to improve media utilisation, increase operating life and reduce lifecycle costs. The results also highlight the importance of humidity management, improved monitoring technologies and consideration of end-of-life disposal when selecting media configurations. The key conclusions of this study are summarised below:

- Impregnated activated carbon should remain the base design for most wastewater OCUs because it provides robust, broad-spectrum odour control and aligns with established industry practice. Iron hydroxide media lacks effectiveness with VOCs and has reduced effectiveness with non  $H_2S$  sulphur species.

- Where  $H_2S$  breakthrough consistently limits bed life, iron hydroxide should be used as a primary layer before impregnated activated carbon.
- Where VOC breakthrough consistently limits performance, VOC-specific or virgin activated carbon should be used in conjunction with impregnated activated carbon.
- Where only  $H_2S$  and VOCs are present, and broader sulphur species are not a concern, iron hydroxide followed by virgin or VOC carbon may be appropriate.
- Iron hydroxide typically provides about 50% longer  $H_2S$  bed life and a 40–50% lower cost per kilogram of sulphur removed than impregnated carbon when used for bulk  $H_2S$  duty (44% longer and 48% lower for the copper impregnated coal based carbon tested compared to iron hydroxide in the same tests).
- Iron hydroxide is more tolerant of saturated conditions and is therefore valuable where existing OCUs operate at or near 100% relative humidity without effective preheating.
- End-of-life handling may also be simpler for iron hydroxide media because it takes up substantially lower VOC and siloxane loadings than activated carbon. This can make landfill disposal easier, subject to local waste classification and contaminant testing. In some applications, there may also be potential for spent iron hydroxide media to be blended with biosolids and exported for beneficial reuse as a fertiliser or soil amendment, where permitted by local regulatory requirements (this disposal method is commonplace in Europe).

## Acknowledgments

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