Water
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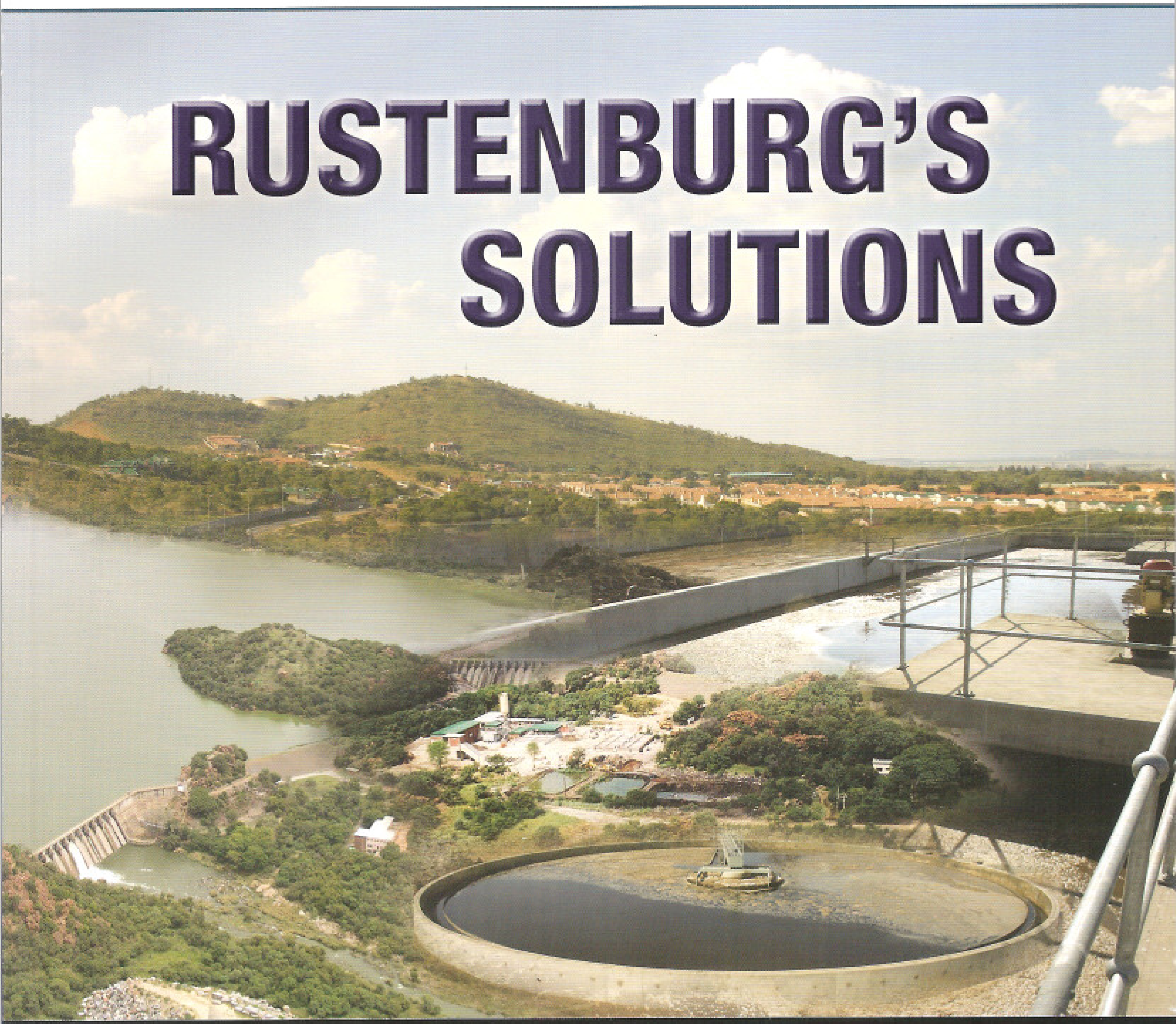
WATER MANAGEMENT SOLUTIONS FOR AFRICA

RUSTENBURG'S SOLUTIONS



Water saving in pulp manufacturing
Odour control technology

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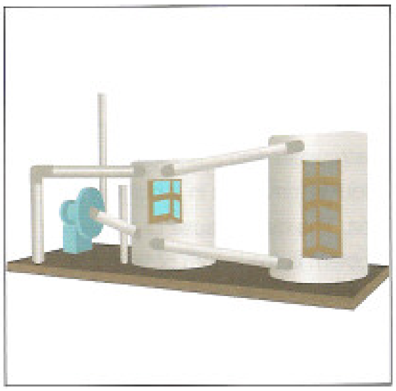

Odour control using bio-filters

Wastewater works and pump stations are known receptacles of odorous substances. *Elizabeth Abelho* looks at bio-filtration as a possible solution to this problem.

eThekwini Water & Sanitation Design Department

Bio-filtration

Bio-filtration is certainly making a statement in odour control as low-cost, environment-friendly and easy-to-maintain. eThekwini Water and Sanitation Department compared the costs of common methods of odour control for its upgrade of the Durban Point pump station (pictured left). Why was bio-filter technology chosen?

Odour control options

Bio-filter technology is the most recent arrival on the scene. What other odour control options are available?

Wastewater and associated odour is inevitable in a built-up area. The major cause of a problem is the length of time it is in transit, giving the gases time to manifest and increase in concentration. It has been proven that nasty smells are detectable at very low concentrations with odour thresholds in the order of single-figure parts per billion (ppb) for many of the offensive substances. The main offenders hydrogen sulphide, volatile fatty acids, dimethyl sulphide and dimethyl disulphide are not discharged to the sewer but are the product of decomposition reactions in the sewage. Bio-filter technology is a relative newcomer in comparison.


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Gas

Hydrogen sulphide gas bubbles off the surface of wastewater as it flows past the mechanical screens. Gas is released in large quantities at all points of turbulence.

1. Adding chemicals to wastewater

Chemical addition (dosing) technologies mainly use mechanisms to feed oxidising compounds to 'raw' sewage in order to oxidise compounds in the wastewater before they can be emitted as odorous gases. Unfortunately, the high organic load of the sewage leads to consumption of large volumes of chemicals because most oxidisers react with all the organic compounds in the wastewater, not just with the odour-causing substances. The non-specific reactions may lead to the formation of volatile organic compounds (VOCs). The chemicals themselves are highly reactive, typically oxygen, ferric chloride ($FeCl_3$), potassium permanganate ($KMnO_4$), ferric nitrate and hydrogen peroxide (H_2O_2) or even toxic (ozone, chlorine dioxide (ClO_2) and sodium hypochlorite (NaOCl), making transportation, handling and storage dangerous and costly. There are a range of proprietary products available for specific applications, such as 'bottom sludge only', which are far safer to use but still have limited applications and the resulting low treatment efficiency does not present a workable solution for removing odour.

2. Chemical 'scrubbing'

A scrubber is an air washer with a refinement device used to remove very fine solids or particulates from gases. Scrubbers can effectively reduce concentrations of certain water-soluble acid, base and organic contaminants. Since the scrubber is so effective at capturing particulates, a filter is necessary to remove them from the system. The filter may be cleanable or disposable. Generally, there are two broad classifications of air pollution control referred to as scrubbers: wet chemical and dry chemical. The use of bio-scrubbers has been added to this category.

Most wet scrubbers use a solution of acids, sodium hypochlorite, hydroxides or other oxidisers to react with compounds in air emissions to control wastewater odour. The chemicals are mixed and sprayed over a packing material within a tower through which the odorous air stream must pass before emission. In addition to the large amounts of dangerous chemicals used and sometimes recirculated under high pressure through external pipes to the tower, the drainage generated from wet scrubbers constitutes another form of wastewater. This wastewater may require pH or other stabilisation prior to release into the wastewater system.

With dry scrubbers, the odorous gas is passed through a packed bed of dry chemicals, such as stabilised chlorine dioxide, which effectively oxidises the sulphides to sulphates, mercaptans to sulphonates, and sulphonic acids and amines to carboxylic acids. Products of the reactions are odourless and environmentally sound; no chlorinated organics are formed.

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Bio-filters

At the Durban Point pump station, bio-filters have been running successfully since October 2004.

Comparison

One solution does not fit all in the selection and application of a particular technology. It is particularly difficult to integrate new technologies into an existing plant with the space, layout and process flow limitations. Over and above this, it is rare for a plant to be shut down for an upgrade.

Considering the alternatives, the advantages of using bio-filtration for wastewater odour control are numerous. In contrast to the addition of chemicals and wet scrubbing, bio-filters do not require transport, storage or handling of caustic or dangerous chemicals. Unlike wet scrubbers, there are no dangerous compounds in the tiny volume of drainage water that may be generated. Where activated carbon systems become saturated with all types of organic compounds, bio-filters specifically destroy odorous chemicals. Rather than transferring odorous pollutants from the air to a solid material for disposal, as happens with carbon, bio-filters eliminate the pollutants almost entirely using natural biological processes. A mildly acidic low hazard waste that can be disposed to general waste landfill is produced.

Finally, bio-filters are distinguished as the most cost-effective solution for wastewater odour control in nearly all cases. A cost comparison between common methods was undertaken by the eThekwini Water and Sanitation Department for an upgrade of the Durban Point pump station. There is no need for ongoing chemical purchases and additional wastewater treatment, and the estimated life of the biological filter media is five years. No caustic or toxic chemicals are used by bio-filters – personnel safety is improved over alternative technologies. Bio-filtration is also the most environment-friendly odour treatment technology available today.

Bio-scrubbers use a tray tower with recirculation of biological mixed liquor through which odorous gas is bubbled upwards. The process requires the addition of a caustic solution to keep the pH at 9. Nutrients have to be added to 'feed' the bacteria and a sump is needed to hold sufficient volume of liquor to prevent loss (by washout) of slower-growing bacteria. Laboratory analysis is also required although the chemical cost is less than that of a wet scrubber.

3. Adsorption by activated carbon

Activated carbon is frequently chosen because of safety concerns about the use and storage of caustic and otherwise dangerous chemicals. Pure activated carbon or activated carbon impregnated with reactive or catalytic chemicals is loaded into large vessels through which the waste air is passed. By physical adsorption to the large surfaces of the carbon particles, organic gases including odorants are removed from the air stream until the carbon is saturated. Following saturation, the carbon must be taken away for thermal or solvent treatment then reused at lower efficiency or replaced with 'virgin' carbon. Since carbon does not specifically remove odorous chemicals, many of its adsorption sites can be loaded with non-odorous organic compounds or even moisture from the air stream, decreasing the functional odour removal lifetime. Frequent removal and replacement of the carbon leads to downtime, maintenance and transportation costs.

4. Bacterial destruction

Bio-filtration has become a preferred treatment for odour control at wastewater treatment plants worldwide. In the Biocube bio-filtration approach, odorous air is humidified, warmed and passed through a biologically active medium (compost) within an insulated, corrosion- and UV-resistant vessel. The odorous gases are firstly dissolved in the water film around the wetted compost particles and then specifically attacked by naturally-occurring bacteria living in the bio-filter media, and transformed by metabolism into water and harmless non-volatile organic compounds. Biocube bio-filter media remains biologically active for five or more years without needing replacement. Liquid waste is not generated, chemical addition is not necessary, and the 'spent' bio-filter media is slightly acidic but completely non-toxic, which makes it a fine soil amendment. Two categories of bio-filtration are noteworthy:

1. single-bed (original concept) and
2. multiple trays (improved version).

Applications using the single-bed approach suffer maintenance issues relating to compaction of the bed and channelling of gases through the media. The improved tray system has evolved as an alternative.

Individually packed trays with biologically active compost are far more effective as this approach precludes deep-packed 'mattress' filter media.

Durban's choice

The choice of a method for odour control is based on capital and maintenance cost, chemicals and efficiency.

The pump station on Durban's Point Road handles 60-million ℓ per day of wastewater – draining from 13 main pump stations across the city. From here, a rising main runs under the harbour mouth to the central wastewater treatment works on the Bluff. The building of luxury residential apartments across the road from the pump station required innovative problem-solving to ensure that odours were kept within legal parameters. The design of the pump station was modelled on a London underground train station with three floors below ground level, a pumping dry well and four circular wet wells. There are another two mechanical screens, ventilation fans, bin-filling facilities, a storage yard, a control room and a 22 m-high stack.

Mungo Graham of the design department within eThekwini Water & Sanitation spoke to *Water Sewage & Effluent* about the evaluation of alternative technologies. Hydrogen sulphide (H_2S) was found to be the main culprit in Durban's sewage so the evaluation hinged on the best method for dealing with it. The capital cost of each of the six common methods was compared, together with a rating of performance in various areas. The costs of chemical treatment methods were all around R4 000/day whereas the biological options evaluated came out at around R14/day.

After examining available options, the Durban team concluded that, by using improved bio-filtration, there would be no chemical costs, no maintenance or operational requirements and, apart from the space needed to install the bio-filtration plant, there would be no drawbacks. Furthermore, physical measures were taken to reduce the volume of gas drawn for treatment, including covers over the four wet wells and air-tight doors in the screenings room. Bio-filters came from Vitacure Systems in Cape Town (in consultation with Odorcure).

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Treatment	Capital cost
wet chemical scrubber	R0,5-million
basic bio-filter	R0,6-million
improved bio-filter	R0,7-million
bio-scrubber	R0,75-million
dry chemical scrubber	R0,75-million
carbon filter	R1-million

The bottom line

Bio-filtration (multiple trays) has a positive effect on capital cost.

Best of the bunch

The bio-filtration process is clearly the best option for the Durban Point pump station.

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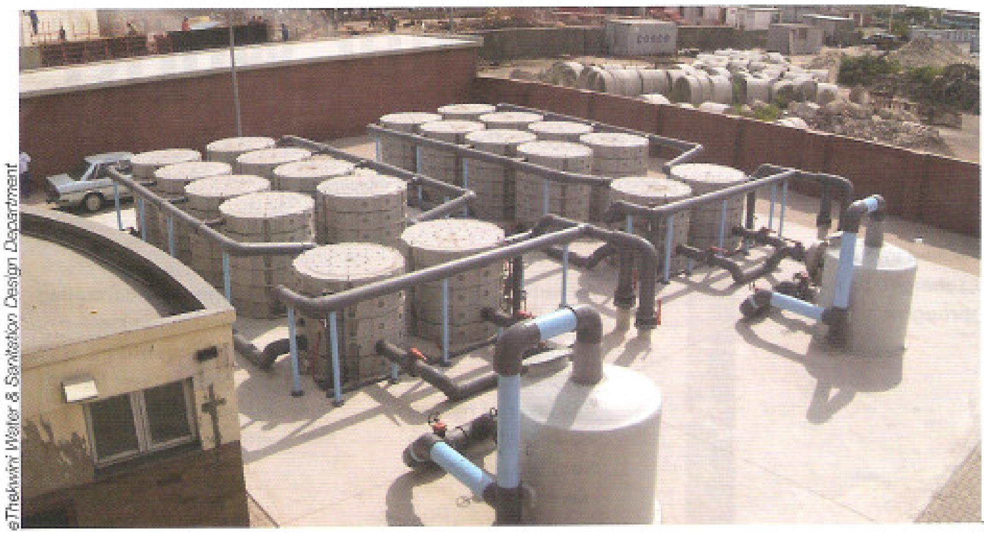
	capital cost	operating cost	hazardous chemicals	corrosive chemicals	maintenance	operational requirements	space	efficiency H_2S	efficiency other
wet chemical scrubber	Lo	Hi	Y	Y	Y	Y	N	Hi	Lo
dry chemical scrubber	Hi	Med	N	N	N	N	N	Hi	Med
carbon filter	Hi	Hi	N	N	Y	Y	N	Hi	Hi
bio-filter	Lo	Lo	N	N	Y	N	Y	Med	Med
bio-scrubber	Hi	Med	N	N	Y	Y	N	Med	Med
improved bio-filter	Med	Lo	N	N	N	N	Y	Hi	Med



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Durban Point pump station

The pump station on Durban's Point Road handles 60-million ℓ per day of wastewater – draining from 13 main pump stations across the city.

Conventional bio-filtration was not favoured due to its low treatment efficiency of 95% together with the problem of media compaction, poor gas distribution and consequent high labour costs to repack the media.

The chosen technology of modular improved bio-filtration avoids these difficulties through the use of trays that improve gas distribution and maintain treatment efficiencies above 99%.

Two streams of emissions are drawn from the pump station:

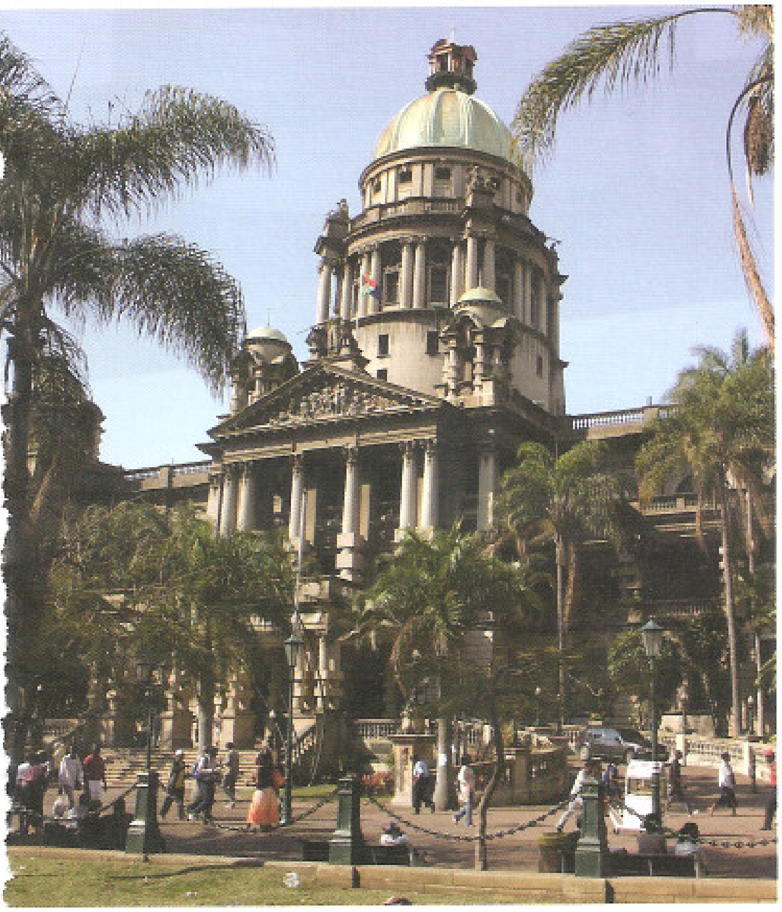
1. on the influent side of the mechanical screens;
2. on the wet-well side of the screens where greater turbulence releases much of the gas from the liquid stream.

Each stream is fed through a Pentpack Biofilter to allow the hydrogen sulphide to be 'eaten' by the bacteria living in the moist layer around the particles of compost.

This is followed by a polishing stage through a granular activated carbon filter.

Sizing the plant requirements was vital. The solution implemented has a capacity of 2 000 m^3/hour, which equates to a capacity to treat 0,13 kg H_2S/hour (assuming maximum concentration of H_2S is 500 ppm). This is more than adequate for the reduced volume being treated after covers were fitted on the wet wells – this reduced the volume of air required treatment by a factor of 9.

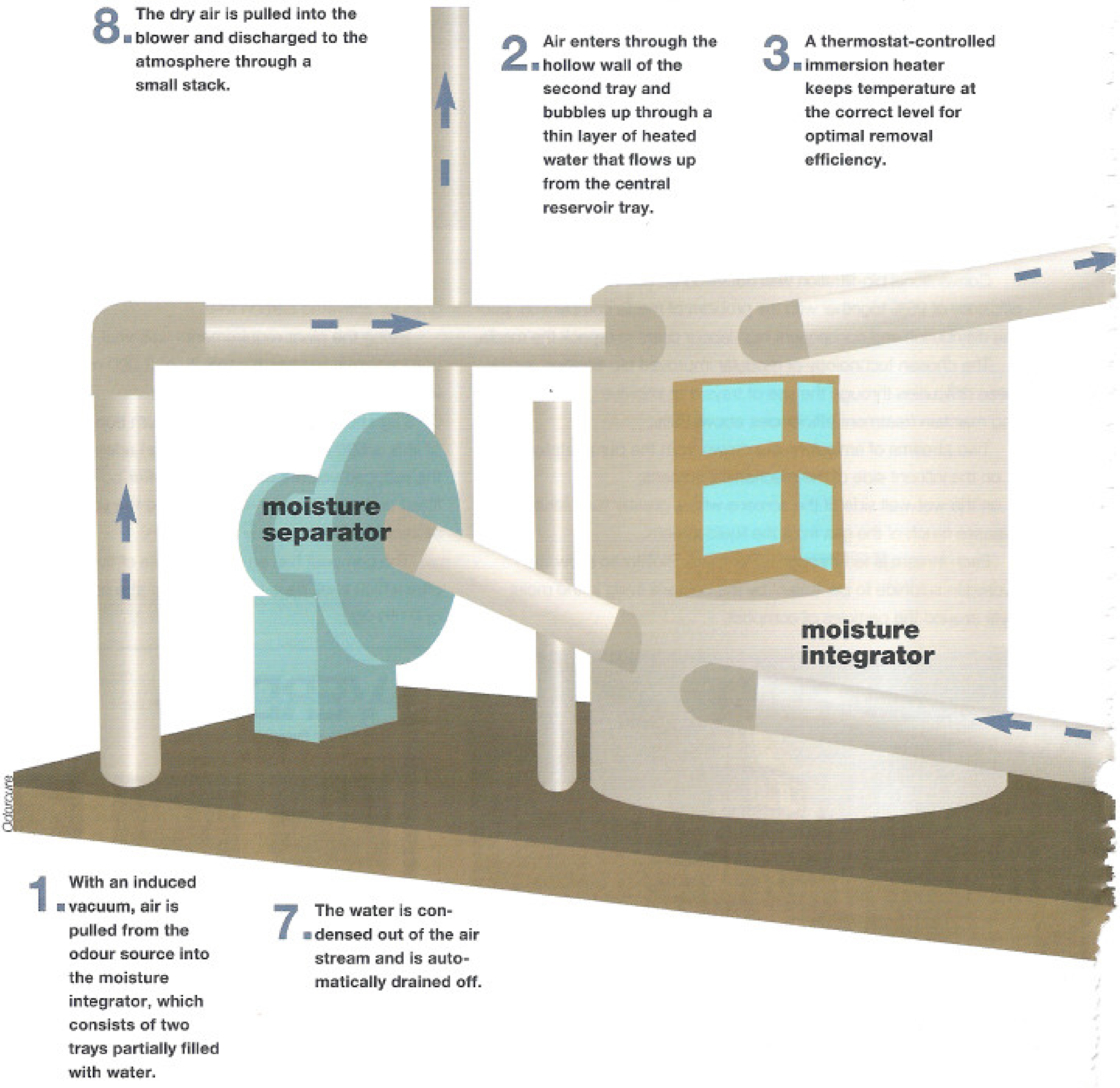
The compost has an estimated life of five years after which it will have to be replaced at a cost of R150 000.



Robin Hayes

How does the bio-filter work?

With bio-filters, bacterial metabolism occurs when foul air passes through a biologically-active filter – bacteria digest the contaminants and thereby neutralise odours.



The entire system operates under an induced vacuum. Air is pulled from the odorous process into the moisture integrator (1) where the humidity and temperature are adjusted for optimum metabolic activity. The moisture integrator consists of three trays partially filled with water. Air enters the inner cavity (2) of the centre tray and bubbles up through a thin layer of water. An electric immersion heater (3) heats the water when needed for freeze protection or to increase efficiency. The humidified air leaves the moisture integrator saturated with water vapour. The air enters the top of the bio-filter (4) and flows down through the biologically active media.

At the base of each tray, a patented plenum (5) assures even air distribution to maximise the productivity of the media. The contaminants are absorbed into the liquid film surrounding the particles of the media. The microbes that oxidise the contaminant live in this liquid film. The oxidation process utilises oxygen out of the air stream and enzymes produced by the microbes to convert H_2S and other

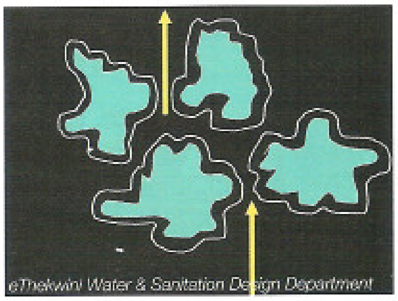
5. The media in each tray contains microbes that oxidise the odour-causing compounds and convert them to sulphates, carbon dioxide and water. The patented plenum design of each tray ensures even distribution of air and moisture without channelling.

4. The air enters at the top of the bio-filters and is pulled down through independent trays of biologically-active media.

6. The odour-free air and a small amount of water vapour exit at the bottom of the bio-filters.

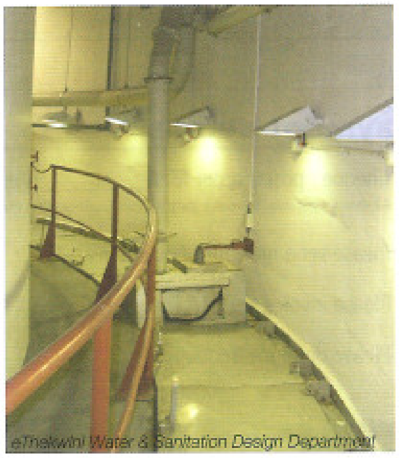
odorous compounds to sulphate, water and carbon dioxide.

Through this process, the microbes receive the energy they need to grow and reproduce. The deodorised air and a small amount of water exit at the bottom of the bio-filter (6). The water and air are separated from one another in the moisture separator (7). Collected water is automatically drained off to a sanitary drain once the separator is full. Dry air is pulled into the blower (8) and discharged to the atmosphere through a small stack. Overall hydrogen sulphide reduction of 99% or greater can be achieved with inlet concentrations up to 1 000 ppm. This level of bio-filter performance is unique to the Biocube Biofilter. ■



Bacterial destruction

Bacterial destruction is the application of bacterial metabolism in bio-filters when foul air is passed through a biologically active filter (or scrubber) in which bacteria digest contaminants and thereby neutralise odours. The bacteria live in the moist film surrounding the particles of compost. The key to the success of a bio-filter system lies in keeping the compost sufficiently moist and warm for the sulphur-eating bacteria to thrive.



Stainless steel covers

The covers – manufactured from 316 stainless steel – were fitted over the open wet wells to reduce the volume of air drawn through the bio-filters for treatment.

Screening

Mechanical screens run up and down this shaft to deposit solids removed from the wastewater – a major source of odour.