Ecotechnologies International

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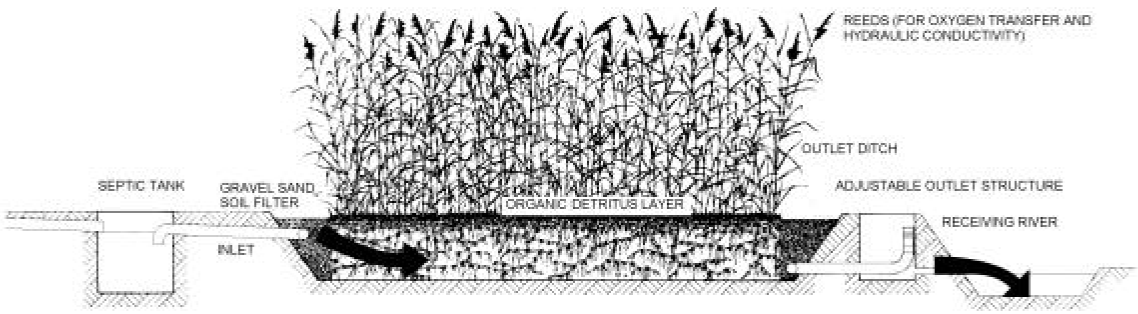
Reed Bed Technology



Reed bed treatment system (horizontal flow)

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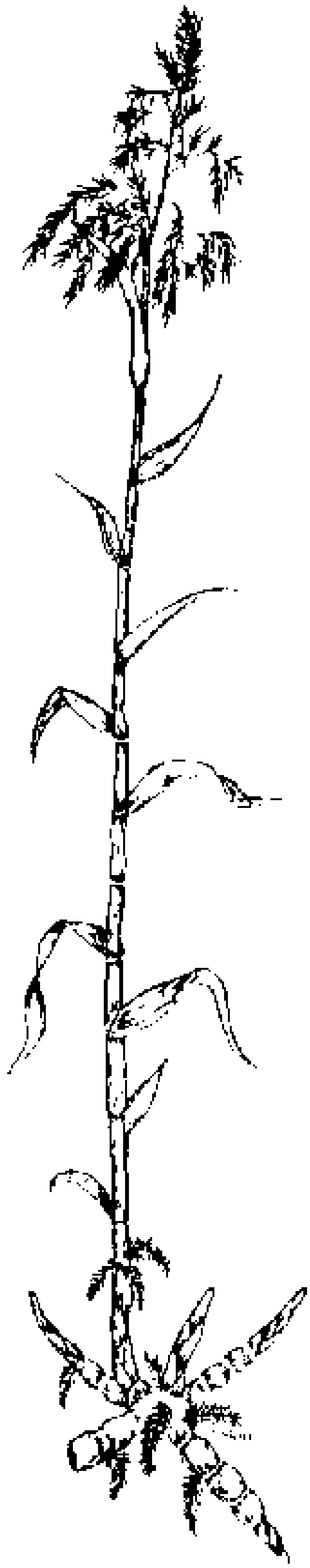
EXECUTIVE SUMMARY



1 Reed bed technology is versatile, has a wide range of applications and can be combined with other technologies and processes to extend the range of effluent problems that can be effectively treated.

2 We are technically one of the most experienced teams in Europe with regard to municipal and industrial applications of reed bed treatment systems.

3 The market for reed bed technology is set to expand worldwide.

1. Our Mission

There are signs of increasing activity in the industrial applications sector of reed bed treatment systems. As legislation tightens and attitudes change, this market is expected to *grow. T*aking an increased share of the municipal and industrial waste treatment market.

Blumberg-Engineers (Ingenieurbüro Blumberg) in Germany is a company which has been specifically set up to address this opportunity through the collaboration and resources of linked companies. Our objective is to establish a major force both technically and commercially in this field ahead of the expansion in the market.

Blumberg-Engineers benefits from the combined experience and skills of our principals, who collectively, form the basis of what is one of the most experienced reed bed technology groups with regard to all applications in Europe and worldwide.

1.1 OUR COMPANY

Our technical team has been intimately involved in this technology from its early stages of development in Germany. We have over 20 years experience in the field, and have built up a comprehensive technical library, which includes original unpublished research papers and records covering practical project implementation.

In association with our partners in other countries, our group represents extensive experience in the successful application of reed bed technology, having completed over 350 large and small scale projects world-wide, including industrial projects across several sectors. Several major projects have been completed for a number of multinational companies including Shell, Esso, Elf Aquitaine, Kimberly Clark, Proctor & Gamble, Zeneca and British Steel.

We are actively pursuing an innovative strategy aimed at transforming the market share available to reed bed technology in the waste treatment industry. We are committed to excellence, innovation, workability and integrity.

Together with our European partners, we have a growing international network of reed bed technology contacts and partners, which provides us with the opportunity to significantly reduce the risks associated with carrying out projects in foreign markets.

Countries in which our group has contracted partners are: Botswana, Colombia, India, Poland, Sweden, Brasil, Switzerland and The Netherlands.
Countries in which our group has developing contacts and projects already realized are further on: Australia, China, Ecuador, India, Indonesia, Iran, Malaysia, Mexico, Namibia, Nepal, New Zealand, Oman, South Africa, Uganda, Austria, South Korea and the USA.

2 SUMMARY OF THE TECHNOLOGY

2.1 Origins

Reed bed technology was developed in Germany in the 1960s by Dr. Käthe Seidel. There has been a lot of international research on this ecotechnological methods since this time and our technical team uses different methods with either horizontal or vertical flow vector or combinations of both or with conventional treatment processes.

2.2 Reed Bed Wastewater Treatment Systems

The principle of this technology is to activate microbial processes that stimulate the natural breakdown of polluting compounds in a specific waste water situation.

This is possible due to the special characteristics of wetland plants, such as reeds, which transfer substantial amounts of atmospheric oxygen through to their root systems encouraging an extraordinary quantity and species diversity of micro-organisms to flourish around their roots.

Reed bed treatment systems essentially comprise self-contained, artificially engineered wetland ecosystems. They utilise particular combinations of plants, soils, bacteria, substrates and hydraulic flow systems to optimise the physical, chemical and microbiological processes naturally present within the root zone of the plants.

Organic pollutants are broken down as a food source by the micro-organisms whilst other contaminants, such as metals or PCB‘s are fixed in humic acid and cation exchange bonds in the soil or mineral substrates in which these plants are rooted.

The complexity of microbial life forms and the reactions within the root zone of the reed bed result in a powerful water cleaning capability which is often much less constrained than in many chemical or physical treatment systems.

Reed bed treatment systems have been successfully used for treating a wide range of wastewater concentrations, from the very dilute up to COD concentrations of 20,000 mg/l and nitrogen concentrations of 4,000 mg/l. They can also handle a wide range of effluent throughputs ranging from small and intermittent flows of about 1 m^3/d to several 10,000 m^3/d.

Functional description

Mechanical-biological treatment of sewage

The sewage will be precleaned mechanically through screens, grit chambers or sedimentation tanks. The reed bed treatment system is selected as an appropriate biological purification stage.

1 Wastewater sedimentation tank

A sedimentation tank is arranged to settle organic substances. Its operation capacity depends on the retention time of the sewage, surface loading and flow velocity. The tanks are designed so that even at maximum inflow a good sedimentation efficiency is achieved. The retention time in this case is about 1.5 days.

The possibilities for sewage sludge utilisation depends on sitespecific conditions.

(One way of further use is a biogas digester. The sludge accumulates in the funnelshaped bottom of the sedimentation tank. The funnels are connected with the biogas digester by a pressure main. Gate valves regulate which funnel is emptied. Then, hydrostatic pressure transports the sludge into the biogas digester for processing.)

2 Pumping station

The pumping station comprises two main pumps (one as a reserve pump) which alternate in operation.

The design of the pumps depends on the hauling volume, the hoisting height and the diameter of the hauling pipe.

3 Reed bed treatment system

The reed bed treatment system combines aerobic and anaerobic decomposition processes in a 1.0 m thick soil or substratum layer. The polyethylene lined and refilled basins are planted with helophytes like *Phragmites communis, Typha latifolia, Typha angustifolia* or other aquatic macrophytes.

The wastewater percolates the filter substrate vertically to the bottom drains.

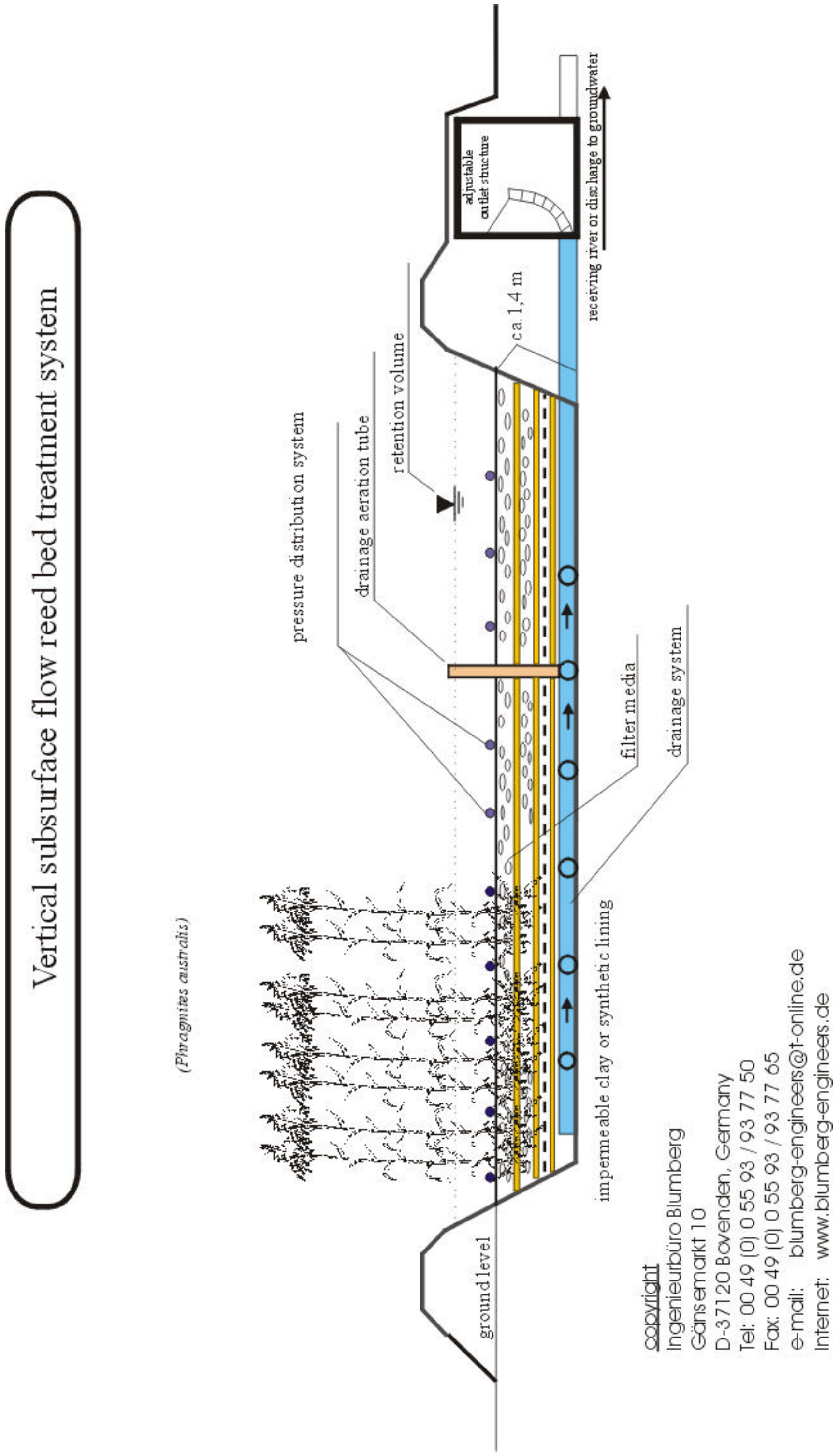
Besides the microbial and fungal decomposition of organic matter and pollutants in the rooted soil or substrate matrix, chemical and physical precipitation, adsorption and filter processes occur due to soil constituents like clay minerals and humus particles. This is most important for phosphate and ammonia binding. Some of the wastewater nitrogen is released out of the artificial ecosystem to the atmosphere as nitrogenous gases (denitrification).

Through intermittent loading of the reed beds a radical change of oxygen regime is achieved. After water saturation by feeding with the distribution system a drainage network at the base collects the purified water. The pore space of the substrate is refilled with air thus enabling aerobic decomposition processes.

Another part of oxygen transfer into the rhizosphere happens through a special helophyte tissue in the plant stems and roots (aerenchym) from the air.

Clogging effects of the filter substrates (soil, sand, gravel) are prevented by the continuous growth and decay of roots and rhizomes of the aquatic macrophytes and the thereby remaining soil macropores. In this manner, long-term water transport into the soil matrix is guaranteed.

The substrate, which is filled in the sealed earth basins, is a sitespecific mixture of selected components determined by aspects of hydraulic conductivity and physico- chemical properties. The soil and substratum mixture is a single case decision of planning further depending on the composition of sewage, whether municipal or industrial.



Scheme of a reed bed treatment system (vertical flow)

By means of high evapotranspiration of the marsh plants the waste water tends to increase pollutant concentrations, thus improving the efficiency of the microbial degradation process. These artificial wetlands reduce both pollutant concentrations and the water volume. Their performance has to be described by - pollutant load parameters (kg BOD / [m² x d]), not just comparing (pollutant)concentrations (mg/l) between inlet and outlet.

The design (length-width ratio, depth, hydraulic loading rate, hydraulic residence time, plant species, soil mixture and so on) depends on sitespecific facts (type of waste water, topography) and on degradation kinetics typical for reed bed treatment systems - in most cases a first order reaction.

The necessary area or volume is further calculated to meet the officially required discharge limits.

Besides proper construction and planting of these artificial wetlands, specialists should supervise the initial phase of the ecosystem development to avoid misfunctions of the total pollution control concept.

Factors influencing the purification process of reed bed treatment systems:

The main factors that typify the treatment characteristics are:

- hydraulic loading rate (m³/[ha x d]) and hydraulic detention time (d)
- temperature
- influent pollutant concentration
- oxygen supply
- development stage of the reed ecosystem

(this sequence is in random order, not according to quantitative importance)

Contaminant removal mechanisms

The physical, chemical and biological contaminant removal mechanisms that are operative in aquatic treatment systems include:

Physical

- Sedimentation
- Filtration
- Adsorption
- Volatilization

Chemical

- Precipitation
- Adsorption
- Hydrolysis reactions
- Oxidation - reduction
- Photochemical reactions

Biological

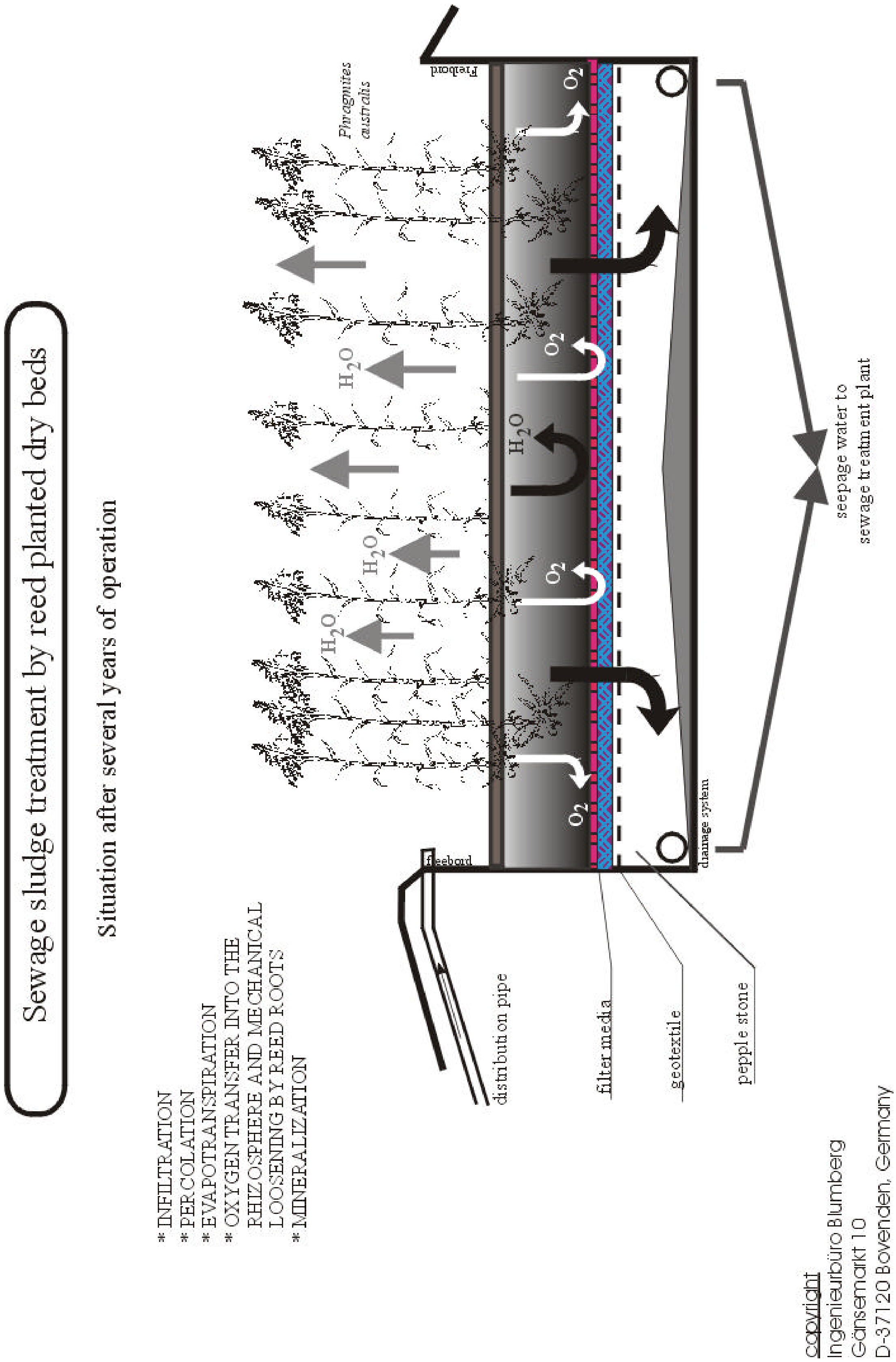
- Bacterial metabolism
- Plant metabolism
- Plant absorption
- Natural die - off

2.3 Reed Bed Sludge Treatment Systems

Reed bed systems can be easily adapted for treating sludges as well as water borne pollutants.

Sludge de-watering and mineralisation is achieved by applying sludge to the surface of specially designed vertical flow systems. The reeds absorb particularly high rates of water which they transpire into the air through their leaves. This process, in combination with an enhanced drainage function and the aerating action of the plants, results in an efficient low cost de-watering of the applied sludges. The de-watered sludge is incorporated into the micro-biologically active top layers of the root zone of reeds where it is mineralised and turned into soil.

Depending on climate, sludge is usually de-watered to a dry matter content of 35 per cent and is reduced to a 5 per cent of its original applied volume over a longer period. Because of the extent of these volume reductions build up of mineralised sludge need only be removed every 10 years. This residue can be transformed into compost, subject to heavy metal content, and used for horticultural, agricultural or landscaping purposes without the need for incineration or landfill.


Sewage sludge treatment by reed planted dry beds
Situation after several years of operation
* INFILTRATION
* PERCOLATION
* EVAPOTRANSPIRATION
* OXYGEN TRANSFER INTO THE RHIZOSPHERE AND MECHANICAL LOOSENING BY REED ROOTS
* MINERALIZATION
Phragmites australis
H_2O
O_2
freebord
distribution pipe
filter media
geotextile
pepple stone
seepage water to sewage treatment plant
copyright
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2.4 System Design

The design of systems depends on the specific wastewater or sludge characteristics and the required level of treatment.

Effluents and waste water can be infiltrated through reed beds both horizontally and vertically and many different materials of varying particle size can be used for plant rooting substrates in ways which transform the performance characteristics of systems.

Each project is custom designed according to effluent characteristics, flow rates and location. Consequently the key to success is in ecological engineering skills and knowing what combinations of variables work and do not work. Some systems combine several design elements and in certain situations are synergistically combined with other treatment technologies.

3 ADVANTAGES AND CONSTRAINTS OF REED BED TREATMENT TECHNOLOGIES

3.1 CONSTRAINTS to the Technology

Reed bed treatment systems have a number of constraints which need to be taken into account when advising clients of their suitability for treating a particular waste problem. Such constraints are:

LARGE LAND AREA REQUIREMENT

The requirement for a much larger land area compared to other treatment technologies.

RUNNING - IN - PERIOD

Many reed bed systems require a longer running-in-period than other treatment technologies before they can achieve their hill operational performance. This is especially so in systems using soil based substrates, as their full hydraulic throughput is directly proportional to the growth and climax development of the planted root zone. Also, particularly harsh concentrations or constituents in the effluent can retard the growth and climax development of the plants and their host micro-organisms. These factors, singly or combined, mean that in some cases a 1 to *3* year period to complete commissioning is necessary.

However, lead in times for reed bed systems to achieve full design performance have continued to reduce over the years as new developments in the make up of substrates, as well as synergistic integration with other biotechnologies have been exploited.

There are now many system designs which can achieve their performance specification from day one.

SEASON AND WEATHER DEPENDANT ACTIVITIES DURING FEASIBILITY STUDIES AND CONSTRUCTION OPERATIONS

Several critical activities involving the use of plants during feasibility and/ or pilot trials, as well as planting and soil operations during the construction of systems, are seasonally constrained and weather dependant.

lt is possible to mitigate this constraint through the use of glass-house laboratories, permanent test beds (fixed or mobile), use of alternative substrates or soil conditioners, greater planting density and/or large containerised planting stock.

POTENTIAL FOR MIS-OPERATION OF LIVING SYSTEMS

In common with other biotechnologies, reed bed technology can only be successfully implemented and operated by clients who genuinely appreciate and understand the constraints and advantages of living systems.

The risk of system mis-operation and associated negative exposure can be overcome by giving appropriate frank advice and recommendations to our clients at the feasibility stage, and through the provision of post construction consultancy and supervision services, including the training of client personnel and the supply of operating manuals.

NOT A STANDALONE SOLUTION TO EVERY TYPE OF WASTE PROBLEM

Reed bed technology alone is not capable of providing the optimum treatment solution to every type of waste problem. There are effluents and sludges with concentrations and/ or types of constituents which are too problematic or unsuitable for primary or secondary treatment in a reed bed system.

However, reed bed systems can be synergistically combined with other technologies, especially other biotechnical systems, (such as a second step to anaerobic digestion for effluents with very high COD levels), so increasing the effective range of application for both technologies.

UNDERSTANDING AND ACKNOWLEDGING CONSTRAINTS DRIVES FORWARD OUR INNOVATION AND COMPETITIVENESS

As skilled professionals committed to excellence, we want to deliver to our clients the overriding benefits of reed bed technology, and therefore, we welcome the challenge of the above constraints as a means to continuously drive forward our innovations and competitiveness.

3.2 ADVANTAGES of the Technology

ROBUST AND EFFECTIVE

It is easy for those unfamiliar with this technology to underestimate the robustness and effectiveness of the natural processes operating within such engineered ecosystems and their powerful cleaning and recycling capability. The composition of micro-organisms in a reed bed system is very versatile with more than 5,000 different types of bacteria compared with 200 - 300 in other biological treatment plants.

CONSISTENT DISCHARGE QUALITY

Such engineered ecosystems have a superior capacity to tolerate wide variations in effluent characteristics, and to withstand shock loadings, without damage or disruption to treatment and so maintaining a consistent discharge quality.

NO BY-PRODUCTS

Reed bed systems produce no noise or smells and no sludges or other by-products with associated additional costs of disposal.

VERSATILITY

A particular strength of the technology is that, although it is not a general panacea for every waste treatment situation, it can be used in many different ways for different purposes. It can be used as primary or secondary treatment for a wide variety of effluents and sludges. To date, we have knowledge of the decomposition of some thousand compounds in reed bed systems.

Reed bed systems can be used to treat effluents which are surprisingly concentrated as well as effluents with difficult pollutants too dilute to treat by conventional means but which remain too dangerous to release into the environment.

Reed bed systems can be used to recycle water and even precious contaminates which are bound into the substrate such as copper.

They can also play a cost effective role in the containment and treatment of storm-water overflows.

LONG LASTING WITH LOW OPERATIONAL & MAINTENANCE COSTS

With little or no electrical or mechanical parts, reed bed systems are long lasting, wear free and naturally regenerative. Being self-regulating ecosystems, they are simple to operate without chemical additives or complex electronic controls and require minimal staffing levels due to their very low maintenance requirements. Consequently operational and energy costs of reed bed systems are very low and system lifetimes are very long.

LOWER CAPITAL COSTS THAN ALTERNATIVE CONVENTIONAL SYSTEMS

Territorial authorities and companies choose reed bed treatment systems on economic grounds. The capital costs of reed bed treatment systems depend on the availability and proximity to the proposed site of natural resources such as land, suitable clay, soils and substrate materials. Generally speaking, the capital costs of reed bed systems are at least comparable to conventional treatment technologies, and depending on circumstances can be up to one third less than conventional treatment systems.

ENVIRONMENTALLY SAFE & BENEFICIAL

Reed bed systems in their construction and operation are environmentally benign, as in essence they are specially engineered ecosystems, using substantially natural components to harness nature‘s own powerful processes. The tall attractive reeds in such systems not only blend pleasantly with the local landscape, but also offer considerable amenity and wildlife conservation potential. As a spin-off benefit, reed bed systems can recreate ,,natural“ wetland habitats which are otherwise fast disappearing around the world, and for this reason alone their use is likely to be enthusiastically supported by many influential people and organisations.

4 EXAMPLES OF INDUSTRIAL APPLICATIONS

STEEL MAKING in South Wales, United Kingdom

Members of our team constructed a very large reed bed in Europe, an 18 hectare system for British Steel which treats a high ammoniacal effluent from their coke oven process, at Llanwern in South Wales.

CHEMICALS in England, United Kingdom

At Billingham on Teeside a 5 hectare system for ICI Zeneca treats a high volume effluent containing phenols, amines, methanol, and acetone with an average BOD of 1,500 mg per litre. It is worth noting the robustness of the reed beds microbial populations in such situations. Other biological treatment systems have difficulties in treating such phenolic effluents, which as biocides can kill off “pollution eating” micro-organisms.

PETROCHEMICALS in Colombia

Systems for treating oil contaminated waste water in the oil and petrochemical industries have also produced impressive results.
In Colombia test results for Argosy Energy International and Elf Aquitaine led to the construction of a 2700 sq metre system treating phenolic wastewater at a daily flow rate of 600-1200 cubic metres. Even at very high flow rates a removal of 60-70% of the COD and phenolics is achieved.

LANDFILL LEACHATES in Germany

A landfill leachate containing a huge cocktail of pollutants, including chlorobenzenes, chlorophenoles, hydrocarbon isomers, polycyclenes, chloroethenes, and aromatic solvents is treated at Hamburg in Northern Germany. The leachate from this 15 hectare former landfill tip also contains dilute concentrations of PCB‘s which are safely trapped and contained within the reed bed substrate. In its first year of operation, concentrations of arsenic and mercury in the leachate were reduced in excess of 80 % and 40 % respectively. Percentage reductions for dilute concentrations (microgrammes per litre) of other contaminates include:
chlorobenzine >98%, 3,4-chlorophenol >92%, ß-hydrocarbons >98.7 %, and naphtalene >99.7%.

PETROL STATIONS AND TRANS-SHIPMENT FACILITIES in Sweden and Denmark

Not all reed bed systems are large scale or require large areas of land. Small containerised systems have been successfully produced for treating wastewaters and sludges at petrol stations and car washes in Sweden and Denmark.

Many other examples could be provided out of the hundreds of systems which our technical team have been involved with.

5 Example Of A Municipal Application

Ecotechnological methods for treatment of waste water and sewage sludge using reed and pond biotopes in Lahstedt – Gadenstedt (near Hanover, Germany)

Registered Project of World Exposition Expo 2000 Hannover, Germany

In contrast to previous methods of sewage treatment using concrete structures and involving complicated technological processes and a high consumption of energy, the Municipality of Lahstedt has decided for its community of Gadenstedt in favour of a combined system of treatment processes which are nature and thus environmentally friendly. When it became necessary to refurbish the existing trickling filter sewage treatment plant (built in 1959), we introduced the three components listed below, which, on account of their appropriate relevance to the theme Man - Nature - Technology and their innovative quality, are to be included among the projects on display at the World Exhibition EXPO 2000 in Hannover:

1 Waste water treatment by means of a reed bed treatment system

2 Combined waste water treatment using unaerated ponds and planted soll filters

3 Sewage sludge dewatering and mineralisation in reed beds

Bovenden in Germany, Februar 2003

(Managing director)

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