Site visit to an Oceans ESU Pesticide Treatment Reedbed

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January 2009

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An independent report reviewing work of Oceans-ESU, a highly respected technical consultancy, specialising in providing sustainable and integrated environmental solutions for a wide range of industrial, retail and municipal applications around the world. contact@oceans-esu.com +44 (0) 1226 785 116

Located in the South East of England, adjacent to a major river, this site was a former pesticide factory. Not only were pesticides produced, but new ones were developed and tested on the surrounding land. (Pesticide chemistry can produce dangerous by-products, nerve gases etc., if not tightly controlled.) The area was thought to be highly contaminated, but no data exists from this earlier period (1980s) to indicate exactly what contaminants might be present. The land was later bought for development, and the Environment Agency required the new owner to decontaminate the area. Oceans-ESU have been contracted since the mid-1990s to remediate this land before any development is allowed to take place.

Initially much of the highly toxic soil was dug out and removed. The housing development immediately to the north now occupies this land area.

The chalk aquifer under this area is important for groundwater drinking supplies, and the pesticides were found to have contaminated this. A reedbed was designed to treat contaminated groundwater and drain the cleansed effluent into the river. Two pumps abstract deep (up to 25m) and shallow (3-5m deep) groundwater and feed this through the wetland. The wetland comprises four reedbeds: two high beds and two lower beds. The northernmost higher beds take the groundwater through a series of pipes dispersing the influent along the west-east width. These drain south into the lower beds. A siphon drain at the bottom collects the treated effluent into a central outflow pipe, which is allowed to drain into a small soakaway field, then into the river, although outflows rarely produce standing water. The reedbed is thus a horizontal sub-surface flow wetland, in which the water flows slowly through the soils. Standing water exists occasionally at the downstream end, although is kept to a minimum by design to reduce smell, and maximise the treatment effectiveness.

The beds were carefully designed by engineers to determine the size, shape, and gradient. The beds are approximately 70cm deep, filled with a soil medium, and planted with *Phragmites australis* (common reed). This reed is native to many regions across the world, it is hardy and grows well. It has a very dense rhizosphere reaching about 50cm deep, which provides excellent conditions for the development the microflora. The beds are lined with thick plastic and geotextile material, which ensures untreated water cannot infiltrate to groundwater. There are no barriers to the site; it is open to the public and wildlife, although the public keep out and are occasionally negative towards it. However, water voles and deer are seen at this site. The retention time of water in the system varies between 2-20 days depending on the groundwater supply and hydrology, but is typically around 10 days, which provides sufficient time for fully effective treatment.

Oceans-ESU reedbeds often undergo three years of monitoring by the company, after which maintenance is taken on by the landowner. Here, the company is continues to maintain it. The reedbed has been in operation for 10 years. Every month Oceans-ESU check the site, and every three months take readings and chemical analysis of the influent, effluent, and shallow and deep groundwater from several boreholes across the site. Maintenance is minimal.

A soil substrate can clog more easily than gravel if incorrectly specified, and this site has not experienced problems which cannot be solved by controlling the inflows and outflows. In any case, soil is preferential to encourage more diverse microbial activity for treatment (for domestic sewage, gravel can be used because the influent brings the microbe population, but will have a much shorter useful operational life due to humus blocking the hydraulic paths between the gravel). Competition by other invasive plants is not generally an issue here, although some bulrushes colonise the wetter outflow end. Weeds can arise when the site dries out (typically in summer, as the groundwater depletes), but these can be killed by flooding the site and drowning them. The system is not harvested, as is occasionally recommended for domestic sewage treatment systems, which can become saturated with nutrients and metals. This wetland was built with enough headroom capacity to treat more groundwater than typically expected, and because of this the system is relatively self-regulating. During the site visit, a cold spell had brought snow and ice. This slows the biological processes, but treatment is thought to not be severely affected unless the cold continues significantly longer (and if a regular seasonal pattern, this can be met with modified design parameters).

Much maintenance is achieved by regulation of hydrology, which is considered an important factor influencing wetlands. The groundwater pumps shut off when the aquifer becomes too dry, so does not adversely affect groundwater supplies in the region. It has treated approximately 230 tonnes groundwater in two months. In its early days, it treated greater quantities of water, but still within capacity. The outflow pipe is a bendy hose which can be raised or lowered to regulate flow through the reedbeds. In summer months it is raised to ensure the reedbeds do not dry out. The suspended solids are removed by sand filters here.

The results always show pesticides in the deep groundwater inflow, and sometimes in shallow groundwater also. Levels of pesticide in the outflow are typically below detectable concentrations in all seasons, which may be considered maximum 100%

removal. Some pesticide categories show typical removal efficiencies of >75%. Other contaminants are not monitored because there is no known additional pollution, although it is likely that the reedbeds effectively remove heavy metal traces as well. Removal of pesticides is achieved predominantly through microbial degradation, but also adsorption onto soil particles and roots, volatilisation into the atmosphere, and photodegredation.

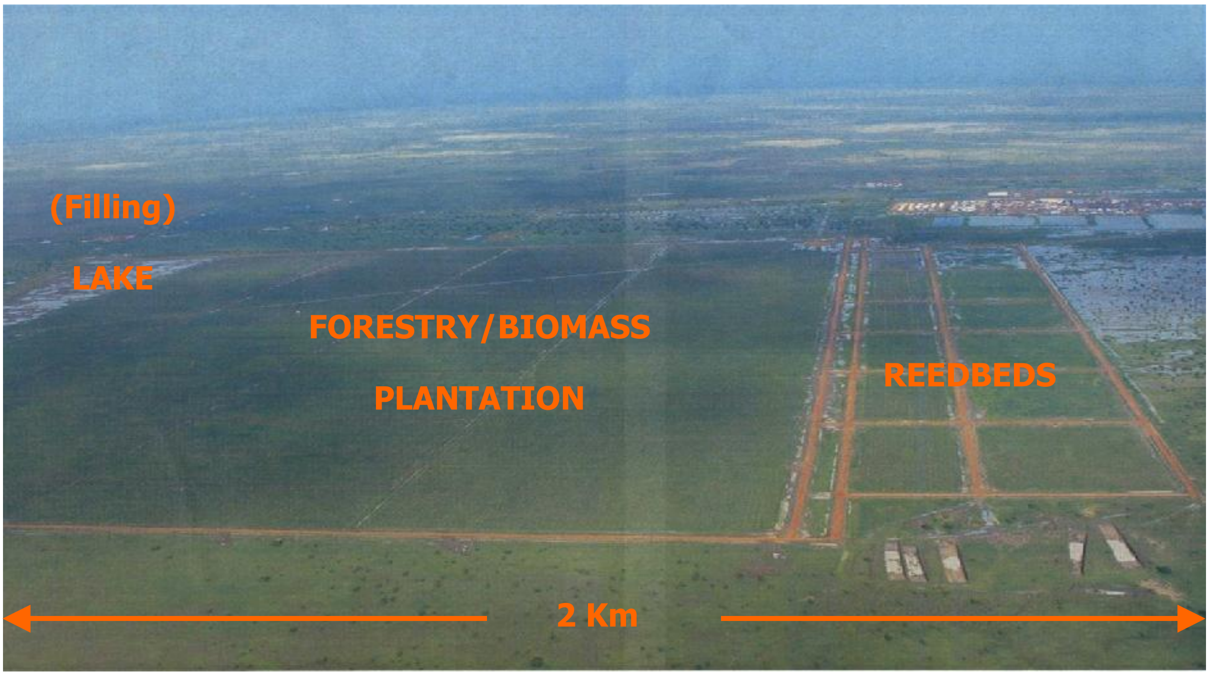
Other reedbed perspectives from Oceans-ESU

In the UK, the Environment Agency grants licenses to operate domestic wastewater treatment reedbeds, but can be resistant to the technology, as also are most water companies. Notably Severn Trent has constructed more than 250 gravel reedbed systems (mostly for tertiary treatment or at remote small sites); this is more systems than all other UK water companies combined.

Resistance to reedbeds (also by public) is thought due to various reasons :

- Lack of confidence in the technology
- Lack of understanding the technology
- There are some poorly installed & maintained systems
- Because it is more open to the environment
- Because it is not 'mainstream'
- Because it is not highly engineered
- Perceived space constraints

Oceans-ESU therefore do most business in Africa and the Middle East in relation to treating water contaminated by dissolved hydro-carbons, a by-product of the oil abstraction and refinery industry. Sudan and Oman have been major projects. Next, it is expected that South Africa and Malaysia will adopt this technology to treat contaminated land, groundwater, domestic and industrial wastewater. In Britain, Oceans-ESU often uses the "disposable" Reeds In a Box technology for temporary treatment. They also designed the reedbed for Sainsbury's flagship Greenwich eco-store, as well as bio-remediation for former steelworks in South Wales, and reedbeds for runoff from petrol station forecourts (instead of conventional interceptors which are ineffective and require emptying).



Reedbed, constructed forest & lake – Sudan (courtesy Oceans-ESU)

The sister company Oceans-Australia sees more demand for domestic treatment due to the remoteness of some homes and the impracticality of a Bazalgette model sewerage system. Although a naturalistic, traditional technology, Oceans-ESU believe the design of effective systems is highly complex and requires good planning and monitoring and they have pioneered the development of this technology in the modern era. Rogue traders in the UK have designed many poor systems which do not treat effectively, which have further affected the reputation and perception of reedbed technology.

The treatment wetlands in Sudan for the Greater Nile Petroleum Company are one of the largest and longest running systems in the world at this scale. The system is 2km wide; design on such scales in flat terrain is a complex engineering feat (to avoid the use of costly pumping, the systems flow under gravity). Oil is settled in lagoons and skimmed off the surface for reuse. It then enters reed beds, then a forestry area and finally a large lake. Oceans-ESU has designed the project to leave a productive, rainwater-harvesting (& generating) ecosystem once the oil production finishes. It treats 50,000 tonnes of water each day, at many times the toxicity (30,000 BOD) of normal combined sewer flows (<5,000 BOD). The treated effluent is regularly tested and achieves less than 3ppm of dissolved hydro-carbon. The Sudanese legislation has fallen from 10ppm limit ten years ago, to 5ppm currently. These concentrations are almost too low to accurately detect, and are done so using fluorescent spectrometry.

The Sudanese government now stipulate all oil companies use Oceans-ESU or equivalent design standards for treatment as the preferred technology. The alternative is hydrocyclone technology to separate the oil, which is expensive and also not very effective. Oceans-ESU operate 14 such sites for petroleum companies. In Sudan, the *Phragmites australis* grow faster and larger than in Britain, where temperatures exceed 40°C, with a distinct wet and dry season. Oceans-ESU designed reedbeds in China can operate at temperatures as low as -40°C. An additional benefit of the Sudan wetlands is the development of the biodiversity and the ecosystem (ecological capital) over a huge surrounding area. A group manages the forestry, working closely with Oceans-ESU. Mosquitoes are not a problem in this site, as it is designed to prevent standing water, and fish naturally predate mosquito larvae in lake. Oceans-ESU is committed to educating the local population and is increasing the Sudanese workforce. It is intended they will become economically self sufficient from the restored ecology once the oil companies leave.

Sudan system lake discharge, 50,000 tonnes of water each day

(courtesy Oceans-ESU)

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