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SETTING THE ENVIRONMENTAL AGENDA SINCE 1970

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The Climategate lessons



When the 'Climategate' scandal broke in December 2009, following the hacking and online publication of thousands of emails from the University of East Anglia's internal servers, many environmentalists must have had their heads in their hands.

Most were quick to realise that the emails did almost nothing to challenge the science of climate change, nor did they suggest that our infant policies and regulations to reduce greenhouse gases were misguided.

But Climategate was hugely damaging for other reasons: it tarnished the reputation of climate scientists the world over, regardless of their professional opinions and papers; it delivered a tremendous shock to the foundations of public belief in man-made global warming; and it offered a battery of ammunition to the conspiracy theorists and outright climate change deniers.

What has been sorely needed since then is an in-depth, dispassionate investigation into exactly what the leaked emails discussed, and what they implied. We now have that investigation, in the form of Fred Pearce's new book, *The Climate Files*.

Anyone who read Pearce's lengthy analyses of the leaked emails published on the Guardian website last winter must have realised that he was working himself up to a book, but few could have anticipated that he would weave such disjointed fragments of information as those that were dug out of the UEA servers into such an impressive analysis of climate science.

Unlike the official investigations into Climategate, which have dealt exclusively with issues of scientific misconduct and accusations that Freedom of Information requests were dealt with unlawfully, Pearce looks at what everyone really wanted to know about the emails: do they suggest that the science of climate change is less certain that we thought?

Environmentalists will find themselves swallowing hard at many points of the book. Elements of climate science that had once been thought of as axiomatic, such as the iconic 'hockey-stick' graph that starred in Al Gore's 'An Inconvenient Truth', and modern temperature data series derived from ground-based thermometers, take a battering. Pearce is quick to defend the UEA scientists and their international colleagues when he sees them being unfairly slandered, but is equally excoriating in his criticism of their methods when he discovers them acting petulantly, covertly or outside the traditions and methods of science.

Pearce's brilliant last chapter, 'Saving the Science', should be read by everyone on the planet. In just a few hundred words, he sets out what we know almost for certain about climate change, what we're reasonably sure about, and where we're just guesstimating. These grey areas in our knowledge, he argues, are not an excuse to relax our attitude towards climate change – they are all the more reason to act quickly, decisively, and with a sound and open discussion of the science.

Mark Anslow, Editor

A mountain of uranium tailings in the Somair uranium mine in Arlit, operated by French company AREVA
Photo © Greenpeace / Philip Reynaers

Think nuclear is clean energy? Ask the Nigeriens

As the new nuclear renaissance grows, so too does uranium extraction. In Niger, which boasts some of the world's richest deposits, NGOs say that the poor are being exploited for the West's 'clean energy'. By **Carolyn Lebel**

In the heart of the Sahara lie some of the world's largest uranium deposits. Until recently, the region had held little interest to the world's trading partners, save France. Desert tribes, predominantly Tuareg nomads, had been mostly free to roam its vast, barren expanse, living off what little bounty it had to offer. Then a few years ago, rising fuel prices and climate change revived interest in the atom.

Countries like Britain, India and the US began reconsidering the nuclear option. In January 2008, the British Government also gave the green light to new nuclear power, arguing that it would be good for the environment and national security. Around the world, and most keenly in emerging economies, new nuclear power programmes were being launched. Uranium was making a comeback.

Niger, one of the world's poorest countries, started to find itself at the centre of a lucrative export market. The government

issued hundreds of exploration permits to prospectors from around the world. The search for uranium covered some 85,000 square kilometres along the Sahara's mineral dense geological fissure.

Single-handedly, the French had already made Niger the world's fourth largest uranium producer. The Paris-based nuclear giant, Areva, had been quietly mining in the region through subsidiaries Somair and Cominak since the early 1970s.

Amid a devastating drought, the company set up shop in the desert. It built housing, constructed roads and funded hospitals. Two mining towns mushroomed out of the desert, in a spot formerly marked by little more than a watering hole. In an area where camels had been the primary mode of transportation, and camel droppings a fuel for cooking, coal was to become the main source of power for the industry.

It was in 2003 that Bruno Chareyron, a nuclear scientist, first came into contact with a Tuareg miner turned campaigner. A director at the CRIIRAD, a French research institute, Chareyron made a living by combing through old uranium mining sites in France, looking at the radioactive legacy left over from the otherwise defunct industry. Tuaregs were worried about what uranium mining was doing to their health and livelihoods, he was told by Almoustapha Alhacen, president of NGO Aghir in' Man.

Chareyron sent over some Geiger counters (to measure radioactivity) along with a device to detect radon gas, a known, but naturally occurring, carcinogen, and visited Niger himself in 2003. There he discovered radioactive scrap metals from the processing mill that were finding their way to a local market and being recycled by locals into cooking pots and wall reinforcements.

Just a few kilometres outside the villages, he saw mountains of mining waste – some 35 million tons of muddy residues from the processing mills, stored in the open, in two massive mounds covering about 60 hectares. The uranium is gone, but the waste retains about 85 per cent of the radioactivity of the original ore. Desert winds, the scientist feared, were carrying toxic dust and gasses from the landfills to nearby communities.

Equipment seized

Beyond these discoveries, Chareyron's first mission to the region was somewhat of a washout. Customs authorities had confiscated his equipment, allegedly acting on orders from Paris.

'We wasted three or four days in Niamey,' said Chareyron. 'They [customs officials] insinuated that if our equipment had been seized, the key was to be found in France, with Areva.'

One bureaucrat was less equivocal: 'Here, you are in France. France is blocking you,' Chareyron claims he was told. Nevertheless, Chareyron managed to bring back water samples, which revealed contamination, and began ringing the alarm bell.

A soft-spoken but tenacious man, Chareyron is a thorn in the side of Areva's polished communications teams. When Chareyron speaks of contaminated water, he knows precisely how Areva – which denies contamination – will respond. 'Any traces of uranium in the water arises naturally from the fact that the mines cut through the aquifer,' he says Areva will say, which it does. What Areva says about the geology of the aquifer is true.

But a recent investigation by Greenpeace confirms that there has been a gradual increase in uranium concentrations in water over the last 20 years, which is likely due to mining. Water samples also revealed traces of dissolved radon gas and other chemicals, which are not monitored by Areva.

Water use

Uranium mining is a thirsty business. Somair and Cominak pump thousands of litres of water daily from the Tarat, a non-renewable reserve last replenished 3,000 years ago. Some 300 million cubic meters – the contents of Lake Windermere in England – have been siphoned over the years, in exchange for 100,000 tons of yellowcake. A number of wells have dried up and levels have dropped by as much as 150 meters in wells close to Akokan, says Chareyron.

By Areva's estimates, nearly one-quarter of the water is gone. The two mines will run for another 15 years. The company plans to build a pipeline to another aquifer, the Teloua, 'where the chemical quality is better,' says Areva.

Alhacen told Greenpeace: 'The fauna has

disappeared. The flora has disappeared. It is a desert country, but there are trees...their roots cannot grow deeper than 60 metres! However, the water tables are now at 300 metres: the trees cannot reach them.'

'Withdrawing water from an aquifer could have an immediate impact on vegetation,' says Dr. Stefan Kröpelin of the University of Cologne, an expert on the Sahara, who is behind recent evidence of its greening. But the growth of mining villages amid the region's fragile ecology could also have contributed to desertification.

The irony is that, in general, the Sahara is become wetter and greener. But not near the mines. 'There is a very clear trend toward the regreening of the Sahara, but only in non-populated areas,' says Kröpelin. 'Once you approach the cities, you see the opposite effect. A tiny increase in rainfall, vegetation and fauna, can not make up for the exponential growth of a population.'

Areva would agree. Beyond the neatly constructed facilities destined for the mining community, is a patchwork of dusty shantytowns where nearly 60,000 people, mostly nomads, reside. The company blames desertification on locals who cut trees for firewood: in Niger barely 6 per cent of people have electricity.

Patchy development

Niger is hardly a picture of health. Ranked dead last on the U.N. Human Development Index, more than half of its population will face hunger this year. A mere third has access to healthcare, and statistically there are over 500 women to each maternity bed.

Areva's hospitals, which delivered basic healthcare freely, were seen as a blessing. But the hospitals themselves became the source of controversy a few years ago, when it was discovered that radioactive rocks from the mines had been used to fill roads, most notably in front of the Akokan clinic. For critics, it was emblematic of Areva's negligence vis-à-vis worker and public health.

'The health care system Areva put in place was deceptive,' says Dr. Michel Brugière of Medecins du Monde, who became embroiled in a two-year battle with Areva, alongside Sherpa, a human rights organisation. 'They set up small clinics that delivered all the basic care, which was perhaps better than what might be found in the public system. But there was absolutely no monitoring of personnel or prevention.'

A study conducted in France, using Areva's own dosimetric data, shows that uranium miners are more likely to die of lung and kidney cancers than the general population. Exposure to radioactivity can also lead to other conditions such as birth defects and leukaemia.

In Niger, however, all is well according to Areva. 'Cancers are extremely rare. During 40

years of mining, not one case has been detected that was thought to have been caused by exposure to ionising radiation. Cancer is an illness found mainly in Western countries with elevated pollution levels and high consumption of rich food, tobacco and alcohol.'

But close reading by the CRIIRAD of a 2000-page internal report by Cominak suggests a more nuanced reality. 'The death

'There has been a gradual increase in uranium levels in water over the last 20 years, likely due to mining'

rate due to respiratory infection in Arlit is 16.19 per cent, compared to 10.95 per cent in Agadez (a desert town far removed from the mining sites) and 8.54 per cent nationwide,' the report reads. 'Sand storms and air pollution from the mines are possible factors that aggravate respiratory conditions in the area.'

A report by Sherpa alleges that mining-related afflictions have likely been misdiagnosed in Areva's hospitals. 'The only confirmed cases of cancer involve people outside the mining companies,' a former hospital employee told Sherpa. 'When these symptoms affect company agents, one talks of malaria, AIDS...'

Grey areas

Both Sherpa and Greenpeace provide anecdotal evidence of people suffering from unknown conditions, possibly linked to the mines. Beyond these accounts, data is sorely lacking.

'We don't know what the situation is today,' said Dr. Brugière. 'The diagnostic must be established,' he said of a recent agreement signed with Areva, and alluding to a batch of health records he'd just received, of some nineteen workers from Areva's former mines in Gabon, who had all succumbed to cancer. But for the Nigeriens, choice is severely limited. As Saoudé Idi, the wife of a former worker told Greenpeace: 'We know there are indeed many, many diseases and risks linked with this work, but at least we have food on the table; we have something to eat.'

Carolyn Lebel is a freelance journalist

A Parrotfish on the north coast of East Timor
 Photo: Nhobgood
bit.ly/99ncNF



Can algae-eating fish save our coral reefs?

Coral reefs are under threat from all quarters – rising temperatures, ocean acidity, fishing practices... But can clever management of certain fish species help the reefs to recover their former glory? By **Anna Taylor**

Coral reefs cover an area of less than a quarter of one percent of all the earth's marine environment, yet they are one of the world's most diverse habitats, supporting one third of all fish species, and have been growing in the world's oceans for 450 million years.

Corals are colonies of tiny individual animals, known as polyps. Formation begins when free-swimming larvae attach to new land created by volcanic activity. The larvae

then grow into polyps, and lay down calcium carbonate (chalk) cups that form the reef.

Corals grow only on the very thin top layer and, over time, end up sitting on top of hundreds of metres of chalk, constantly growing upwards.

A young Charles Darwin became enthralled by coral reefs on his epic Beagle voyage, and made their formation the subject of his first scientific publication. On seeing them in the Indian Ocean in 1836, he wrote in his journal,

'we feel surprise when travellers tell us of the vast dimensions of the Pyramids and other great ruins, but how utterly insignificant are the greatest of these, when compared to these mountains of stone accumulated by the agency of various minute and tender animals!'

Yet these mountains cannot grow alone. Attached to the coral are microscopic algae that photosynthesise sugars. To do this, algae use sunlight and nutrients which the coral has absorbed from the water or gained from feeding on plankton. Some of the sugars are passed back to the coral from the algae, thus maintaining a mutually beneficial arrangement.

It is the algae, not the coral, that gives the reef such incredible colours, but when conditions are not optimal for algal growth, the relationship breaks down and the algae leave the coral. The reef is left pale and lifeless in a process known as bleaching, which has the potential to devastate coral reefs. Nadia

Bood from WWF explains: 'Reefs are sensitive to climate change. Ocean temperatures need only to increase by one or two degrees Celsius over relatively short time periods for reefs to undergo bleaching. Coral death may occur when such stress is severe or prolonged.'

Climate change is now their greatest threat, and many scientists view coral reefs as early warning systems of a changing planet. In the words of Steve Jones in his book *Coral: A Pessimist in Paradise*, they have become 'a canary in the ecological coalmine'.

Coral 'phase-shifts'

Globally, 15 per cent of coral cover is under imminent threat of loss within the next 10-20 years. Reefs are also suffering because of their proximity to land.

'Rapid coastal population growth, habitat alteration and unsound tourism activities have increased the exploitation of reef ecosystems, thereby threatening the health of the reef,' says Bood. 'Siltation resulting from deforestation, erosion, dredging, mining and other land-altering activities, is a significant factor contributing to reef degradation.' Large quantities of mud and sand run-off from the land smother reef organisms, and block out the light algae need to survive.

It is clear that the algae upon which coral depend are jeopardised by man's activities. However, if the opposite happens, and algae survive and grow a bit too well, a 'phase-shift' occurs. The reef changes from being dominated by coral, to being dominated by algae. This spells disaster for the reef, as the algae can out-compete coral for space to grow. This happens when the herbivorous fish that eat the algae, and keep its growth in check, are removed due to overfishing.

Scientists from Exeter University have demonstrated that one particular species, the parrotfish, effectively controls algae, and should therefore be targeted for protection. Lead researcher Professor Peter Mumby says: 'parrotfish consume algae and while algae are a natural part of any reef, too much algae causes problems for corals. It reduces the space available for larval corals to settle and recolonise the reef, and algae also abrade living coral, causing their growth to slow down, and sometimes direct overgrowth and death.'

The study was carried out over two and a half years in the Bahamas, where coral has suffered from bleaching. In heavily fished areas, no increase in coral cover occurred, but inside marine reserves, where fishing is banned, cover increased by an impressive 19 per cent. The presence of parrotfish allowed

'25-35 per cent of marine habitats should be no-fishing zones to provide effective protection'

coral to grow freely without competition from algae, highlighting the role the fish play in the ability of coral reefs to recover from serious damage.

The identification of this important species means that governments can now put legislation in place to protect parrotfish and hence secure the future of reefs, as well as the local communities dependent on fishing. 'Most fisheries species require a complex reef habitat and this is built by corals. Parrotfish help ensure that the corals can build this habitat and therefore help ensure the long term sustainability of the wider fishery,' said Professor Mumby.

Reef mowers

Another study that set out to monitor the recovery of coral reefs from 'phase-shifts' made some surprising discoveries. A team of scientists led by Professor David Bellwood of the Australian Research Council Centre of Excellence for Coral Reef Studies, deliberately triggered a shift to severe algal dominance, a 'weedy' state, on the Great Barrier Reef by covering certain areas with cages to keep fish out. The scientists then set up underwater cameras to monitor what happened when the cages were removed.

Disappointingly, on particularly weedy patches, parrotfish merely pecked at the growth, and made little impression. However, another fish came to the rescue. 'These batfish showed up and got stuck into it,' said Professor Bellwood. 'In five days they halved the amount of weed. In eight weeks it was completely gone and the coral was free to grow unhindered.' It came as a surprise to the researchers, as this species of batfish was previously thought to feed only on invertebrates.

Two years later, another helpful herbivore appeared on the scene. Schools of up to 15 rabbitfish were recorded feeding at more than ten times the rate of other herbivores.

'The rabbitfish is not a fish you tend to take a lot of notice of,' said Bellwood. 'Like its terrestrial namesake, it is brown, bland and easily overlooked – but it could be very important when it comes to protecting the Great Barrier Reef. We hadn't seen it previously at this site despite conducting over 100 visual censuses. This made its appearance in numbers sufficient to check the weedy growth all the more remarkable.'

These new discoveries made up for the disappointment of learning that parrotfish, with their ability to 'mow' algae, cannot reverse well-established, thick algal blooms. But neither can we rely on batfish and rabbitfish to save coral reefs, as they are threatened in many parts of the world. Their large size makes them attractive to spear-fishermen, and the more herbivores that are removed from the ecosystem, the more the algae will flourish, causing problems for the reef.

Helping the herbivores

Total fishing bans are a successful way of protecting herbivores, as used in marine reserves, but it is estimated that 25-35 per cent of marine habitats should be no-fishing zones to provide effective protection, and this could cause conflict with growing coastal communities. Designating Marine Protected Areas (MPAs) may go some way to solve this problem. Inside these areas, fishing is allowed but restricted and harmful fishing methods discouraged to ensure sustainability of both reef and fisheries, and recent research has proved this to be effective in the long term.

Dr Elizabeth Selig from Conservation International analysed MPAs in 83 countries and found that 'on average, coral cover in protected areas remained constant, but declined on unprotected reefs. The benefits to coral generally increased with the number of years that they were protected.'

However, our climate is changing, and even the best protection will not save coral reefs from this particular threat. 'The benefits from MPAs likely will not be great enough to offset losses from coral bleaching as a result of ocean temperature increases,' said Dr Selig. 'It is imperative that we work at national and international levels to reduce the activities that cause climate change.'

Hundreds of millions of people in the tropics depend on coral reefs, not only for food and income from fishing, but also because reefs protect the shoreline by acting as a natural buffer against storms. Well-managed eco-tourism can also generate vast sums of money in some of the poorest countries in the world. It must be proven that a healthy, functioning reef is more valuable than a dead one.

Coral reefs, long a symbol of the beauty of nature, are now a symbol of its decline, but if the threats to vital herbivorous fish are addressed, there is hope for the future. Nevertheless, the threats faced by reefs today now are unprecedented in their long history.

Anna Taylor is a freelance journalist

'In five days, the batfish had halved the amount of weed, and in eight weeks it was completely gone'



Planting pine tree saplings - the route found by the Gaviotas community to a productive and sustainable ecosystem
Photo © Michael Buick

The community of Las Gaviotas ('Gulls' in Spanish) is two days drive into the middle of nowhere. Forty years ago a brilliant young dreamer, Paolo Lugari, decided that for once he wanted to see the sustainable dream made into reality, and while flying over the 'wet desert' of Los Llanos in his native Colombia was gripped by the vision that if you could live sustainably there, you could do it anywhere. So, gathering a team of scientists, artists and indigenous Guahibo people, together they founded a community that has consistently achieved the impossible, innovating and adapting decade after decade.

Despite achieving an almost mythical status in the seventies and eighties, winning accolades and worldwide attention, Gaviotas has largely dropped off the sustainability radar, isolated by Colombia's political violence. Until recently. I joined the first visit for years in March to see the remarkable place for myself.

Doing the impossible

Lugari is the undeniably charismatic founder of Gaviotas. A large-framed man, his solid features break easily into an infectious grin, betraying the childlike playfulness and enthusiasm that have driven him for over sixty years. Living in Bogota and based at the 'Centro Las Gaviotas' there, he is the community's connection to the outside world, its spokesman, fund-raiser and self-styled 'complexist'. His fondness for quoting Leonardo Da Vinci reflects his driving passion for thinking beyond established categories. His favourite saying, and a good summary of the Gaviotas philosophy, is 'AVV - alli vamos viendo' - 'we'll see as we go along'.

Gaviotas' early decades were a tornado of technological innovation. Conventional wisdom said the winds of Los Llanos were too light for turbines to work effectively. After 57 prototypes in the early 1970s, the community showed that this was false, achieving a ground-breaking windmill design made from simple, inexpensive materials. Its double-action pump can lift 5000 litres of water a day from a depth of twenty meters.

A second piece of accepted wisdom - that hand water pumps could only draw water from a maximum depth of ten metres - was proven false when Gaviotas' engineers developed a clever sleeve pump that works like lifting water in a straw, from a depth of up to a depth of forty meters.

Some of the most brilliant innovations came from team members who had learnt their skills not at university but in the workshop. On the cusp of the nascent 'appropriate technology' movement, Gaviotas started to draw attention. Inspired by what it saw on a visit in 1976, the United Nations Development Programme designated Gaviotas a model community and provided funding to develop its designs and disseminate

Las Gaviotas: Proving sustainable living possible where it shouldn't be

How one Colombian community put wind turbines where they shouldn't have turned, water pumps where they shouldn't have worked, and planted a forest in soils thought long dead. By **Michael Buick**

nate them internationally. The brilliant manuals for wind turbine and water pump construction read like comic books – technology by the people for the people.

The fortunes of oil

Its creative engineering was a reflection of the community as a whole. An ‘all-archy’, Gaviotas has no conventional hierarchy. One year guerrillas arrived, guns in hand, demanding to know: ‘which of you is in charge?’.

‘We all are,’ was the reply as the community lined up. Asking the commandante if his men intended to take anyone hostage, he replied: ‘No, our orders are not to touch anybody here. What you are doing is too valuable.’

Decisions are made collectively by consensus and not once in four decades has a memo been circulated or minutes taken. There is no police force. No official rule book.

Riding the wave of interest and changed economics that followed the 1973 oil shock, Gaviotas founded a factory in Bogota that employed street kids to manufacture its innovative solar water heaters. The Colombian president installed one on his roof and soon Gaviotas was involved with large scale building projects including Ciudad Tunal, a 5,500 unit apartment complex that remains one of the largest solar-water-heated constructions in the world. The distinctive spherical water tanks of the solar system soon popped up in cities all over Colombia and were duly nicknamed, ‘Lugari’s balls’.



Paolo Lugari, founder of the Gaviotas community
Photo © Michael Buick

Meanwhile, the world, queuing at the petrol pumps, was waking up to the instability of fossil fuels, and Gaviotas found itself in the vanguard of a new and very possible future. Yet we all know what happened next. The oil derricks found their rhythm once again and the new future dwindled into the distance. Gaviotas’ ingenious solar technologies were suddenly no longer so exciting.

Production fell. Salaries went unpaid. And growing violence between guerrillas and paramilitaries buried projections of community growth – some were even leaving in fear of their lives. It looked like the dream could end. But Lugari was pragmatic.

‘What other people call problems we have to see as solutions,’ he insisted, and this difficult time led to perhaps the most remarkable part of the Gaviotas story.

Pine salvation

The answer of how to adapt came, surprisingly, from the soils of Los Llanos. These, Lugari had been told, were so acidic and infertile that it would be impossible to grow anything useful there. ‘The only deserts are the deserts of the mind,’ Lugari had responded - and he would be proved right.

Gaviotas had experimented with crops for years without success, until Lugari returned from a visit to Venezuela with the suggestion that they try Caribbean Pine. This species looked promising, but it was only when the Gaviotans started to inoculate the roots with certain type of fungus – pizolithus

tinctorius – that the trees really took. Forming mycorrhizas, the fungus allowed the pines to thrive, and, since the community had chosen not to clear around the trees (as is common in commercial forestry), the fungus reproduced naturally. At last the community had found a crop that would grow. They started to plant a forest without yet knowing exactly what it would provide. In 1994 they worked a heroic twenty-four days round the clock to plant a million trees before the rains ended. With funding half from Japan (based on carbon sequestration) and half from their own savings (from the solar water heater sales) they planted a whopping 8000 hectares without knowing exactly what the trees would provide.

Their faith was rewarded. In the following years, as their solar business withered, they discovered that the resin of the pines could be sustainably harvested and processed into ‘colofonia’, a high value raw material used in all sorts of products from paints to make-up. A neat little finger of bark is stripped and a plastic bag stapled below to catch the resin. Stepping into the factory I watched Gaviotans unloading a trailer of the resin-filled bags into a series of shiny steel tanks, at the end of which a masked worker used a hose to deposit the hot resin in boxes. The factory also holds the world’s first pine biodiesel plant that supplies the Gaviotas tractors with fuel.

In a further twist, the Gaviotans discovered that their pines were sheltering the rebirth of the rainforest. Over 180 native species sprung up, blurring the neat rows and filling the forest with wildlife. Through determination and creativity, Gaviotas now has a sustainable harvest while regenerating an ancient forest ecosystem not seen on Los Llanos for millennia. No wonder Lugari’s most passionate refrain is our need to repair what he calls ‘the vegetable skin of the earth’.

There are 250 million hectares of similar land in South America alone – why not reforest it all, asks Lugari, producing sustainable harvests of biofuel and materials, soaking up carbon and ultimately restoring an ecosystem?

Gaviotas continues to be an inspiration to the world. This tiny community, nestled in a tropical forest of its own making, declares that another way is possible, that we could survive if we chose to, and that ‘the only deserts are the deserts of the mind’. Do we have enough time to halt runaway climate change, enough support to change our politics, enough land to feed the world without fossil fuels? To these questions Lugari does not claim to have clear answers, but he’s sure of one thing: ‘The real crisis isn’t a lack of resources: it’s a lack of imagination’.

Michael Buick is a freelance writer currently travelling through Latin America visiting sustainable communities and publishing their stories at www.growingwiser.net



Cubes of pine tree resin in the Gaviotas factory
Photo © Michael Buick

The Findhorn Living Machine, courtesy of the Findhorn Foundation

THE LIVING MACHINE: AN ECOLOGICAL APPROACH TO POO

By mimicking the purifying behaviour of wetland ecosystems we can deal with our sewage using one quarter of the energy, and a fraction of the smell... By **Tafline Laylin**

Most wastewater treatment plants squat on the seedy outskirts of towns. Drab, energy intensive and fetid, they use harsh chemicals and can be ineffective against certain pathogens.

For decades scientists have been investigating healthier and smarter alternatives to conventional treatment systems. In the 1940s and 50s, despite the belief that higher plants can't withstand polluted waters, Dr Käthe Seidel from The Max Planck Society discovered that bulrushes don't just survive polluted conditions, they restore them. This earned her the mocking moniker 'Bulrush Kate', but did not prevent Seidel from developing a system of basins containing plants that transformed polluted water into a cleaner end product. In time, though, it became clear that microorganisms, not plants, are the heavy-weight cleaners.

Following in Seidel's footsteps, the ecologist H.T. Odum created guiding principles for the emergent fields of ecological design and ecological engineering. These principles were based on his conviction that a sustainable future depends on our ability to incorporate nature's closed-loop, systemic design into our own. Dr John Todd picked up the baton in the early 1970s. After experimenting with ecologically engineered

solutions to various other applications, including architecture, aquaculture, and food production, the Canadian biologist developed what he called the 'Living Machine'. This is a biologically sophisticated, low energy wastewater treatment system that mimics natural purifying mechanisms such as marshes and wetlands. The machine is also beautiful. So beautiful, in fact, that black and grey water could be treated under our noses and we would bend down for a whiff.

A first at Findhorn

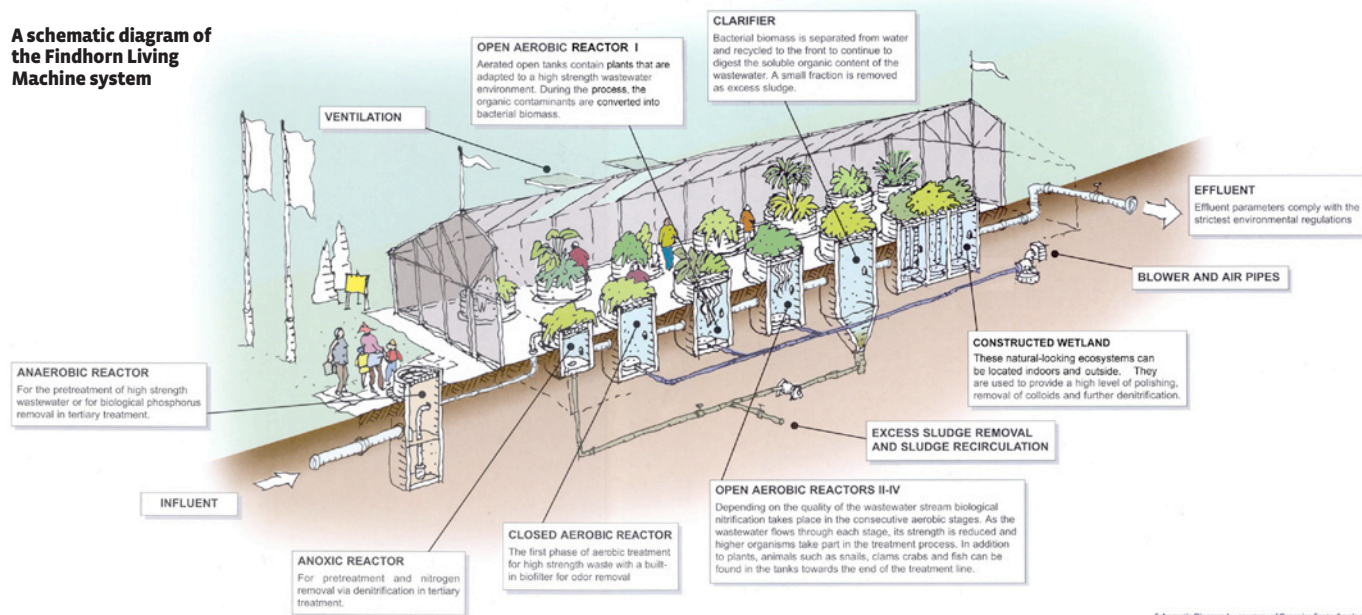
The first Living Machine was installed in 1995 at the world-renowned Findhorn Ecovillage in Moray, Scotland, and continues to treat the waste of approximately 300 people. Here's how it's done: sewage is first collected in three 30m³ anaerobic tanks that are buried outside of the greenhouse (where the rest of the system is stored). The tanks encourage the growth of anaerobic bacteria, which break down organic and inorganic materials. According to Michael Shaw, a founding member of The Ecovillage Institute at Findhorn who was present when the Living Machine was installed, the bacteria that form in anaerobic environments are among the oldest life forms on Earth, up to 3,000 million years old. Inside the greenhouse are two rows

of nine tanks that operate in parallel. After becoming sufficiently soupy in the initial septic tanks, the water flows by gravity to the fourth, closed tank inside the greenhouse, where air bubbles are ushered in to convert the effluent to an aerobic state. The introduction of oxygen kills anaerobic bacteria, giving off a gas that is then filtered out to prevent odours.

The most important task of the next four open aerobic reactors is to maximize the surface area on which a diverse array of microbial communities, or biofilm, can flourish and therefore digest particles in the water. Diversity, as elsewhere in nature, is key to resilience. To achieve this, suspended plant racks support plants with long roots upon which bacteria multiply. Daffodils are among those that Findhorn uses, though any long-rooted plant that can withstand high strength wastewater will work. These plants also consume nutrients and destroy harmful pathogens in the water, which is so rich, according to Sukanya, who maintains the Living Machine, that duckweed trebles its usual growth of 20-30cm each day.

In the next clarifier tank, activated sludge flock, which is a sticky substance comprised of free-swimming bacteria that clump together, separates from the rest of the water

A schematic diagram of the Findhorn Living Machine system



Schematic Diagram by courtesy of Organica Ecotechnologies

and sinks to the bottom of the tank. This sludge is then shuttled back to the first anaerobic tank for another round of treatment. Shaw notes that whereas many wastewater treatment facilities dispose of their sludge daily, Findhorn only disposes of its every four or five years. As a result, the system is less environmentally hazardous, less expensive – and including gas used to keep the greenhouse at 5°C as well as electricity required by aeration pumps – only uses 40,000 kWh annually.

Dealing with nitrogen

Whether achieved conventionally or holistically, the final task of any water treatment system remains the same: nitrify ammonia, denitrify the resulting nitrate, and remove phosphorus. The majority of this work occurs in the next three ecological fluidised beds. Filled with highly porous material (such as gravel) that ‘carries’ biofilm, the beds are subjected to alternating anaerobic and aerobic treatments facilitated with special air pumps. According to original Living Technologies Ltd. literature, the ‘aerobic operation provides reductions in Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS), while the anaerobic operation enables denitrification.

Finally, this polished water is sent to a pond before the water is pumped underground to nearby sand dunes in Moray. The Scottish Environmental Protection Agency (SEPA) regularly conducts quality checks, and in the fifteen years of its operation, Findhorn’s Living Machine has never been out of compliance. The genius of the system is the genius of nature: virtually nothing goes to waste. Every organism provides food for the next step in the food chain until the cycle is complete. Of course, an even more complete system would pump the finished product back

to use for non-potable purposes, but the Living Machine at Findhorn was a first generation installation that has since undergone numerous permutations. Today, the trademark Living Machine technology is offered exclusively by Worrell Water Technologies, LLC, while Dr Todd and others have split off in different directions around the world.

The next generation

Worrell’s most recent development borrows its inspiration from tidal wetlands. Wetland ecosystems act as a buffer zone: stormwater runoff from either urban or agricultural land, sewage discharge or other contaminated water flows into the tidal wetland, which then naturally purifies the water before it is released to rivers or bays. According to the Queensland Environmental Protection Agency, a healthy wetland system, which floods and drains twice a day, ensures that water is suitable for drinking and for other uses such as irrigation and industry. When Worrell took over the Living Machine, he wanted to do away with the activated sludge and the secondary clarifier stage of water treatment.

By incorporating tidal wetland ecology into the Tidal Wetland Living Machine System® (TWLM), while maintaining the basic steps of the original technology, he was able to do just that.

After the initial septic treatment, water in the TWLM is flushed through a series of wetland cells that are flooded and drained, which transfers oxygen to the wastewater. Compared to the TWLM, Findhorn’s aeration pumps devour energy. Austin and Nivala wrote in *Ecological Engineering* that tidal wetland systems reduce the energy demand to about 25 per cent of that required by activated sludge systems.

Also, nitrification and denitrification occur

differently: nitrification takes place when the wetland cells are drained, and denitrification occurs when they are flooded. This cycle may occur up to fourteen times a day depending on how heavily loaded the wastewater is, says Will Kirksey, Worrell Water Technologies’ Vice President, and eradicates methane and nitrate byproducts.

A commercial reality

In a testament to the growing acceptability of the technology, the Port of Portland in the US recently commissioned Worrell to produce a TWLM system to treat 5,000 gallons of their wastewater each day. At the end of the flood and drain cycles, the water is disinfected as an extra precaution before it is returned to the system for cooling towers, and to flush toilets.

The TWLM system also includes internet-operated control technology that can be modified with on-site touch screens, and even has an iPhone application that can adjust cycle frequency as necessary. When questioned about using advanced technology despite ecology’s proven finesse, Kirksey responds that technology may not replace nature, but it can help nature to restore itself.

The experience at Findhorn demonstrates, however, that while the microorganisms and plants bloom, the human component is more fallible: Sukanya frequently fishes out bottles and other rubbish that are flushed through and block Findhorn’s sewage system. Or the pumps – which cost approximately £1,000 each – wear out and have to be replaced. Still, the TWLM boasts exceptional water treatment, with no theoretical limit to potential capacity, that can be used in municipalities, residential and office developments, schools, hotels, zoos, farms, and other facilities.

Taflin Laylin is a freelance journalist



Get down off your Dark Mountain: you're making matters worse

Highlighting the challenges we face is one thing; revelling in social collapse is quite another, says **Solitaire Townsend...**

'The End of the Universe is very popular', said Zaphod... 'People like to dress up for it...gives it a sense of occasion.'

In Douglas Adams' *The Restaurant at the End of the Universe*, diners enjoyed watching the obliteration of life, the universe and everything, whilst enjoying a nice steak.

When I first discovered The Dark Mountain Project I couldn't help secretly hoping a bunch of uber-cool hipsters were making an ironic analogy between our current climate challenge, and Adams' satire. Of course, it turns out there wasn't a drop of irony involved.

This project/art installation/book/festival, 'starts with our sense that civilisation as we have known it is coming to an end; brought down by a rapidly changing climate, a cancerous economic system and the ongoing mass destruction of the non-human world'.

Basically, the end of the world is nigh and there is sod all you can do about it. Extrapolate forward from their Principles of Uncivilisation and you'll find that a bunch of us are going to be washed away but a few survivors will live in harmony with nature.

This is pretty gloomy stuff, even for two ex-journalists (a breed who seem often rained upon). But Paul Kingsnorth and Dougal Hine have decided that life as we know it is over, the collapse is coming and it's time to essentially turn off and restart human (particularly western capitalist) systems.

An orgy of Armageddon

My mounting frustration with Dark Mountain isn't their brutal honesty about the problems, but a growing suspicion that, like the diners at the Restaurant, they are enjoying the show.

Their festival pamphlet reads like an orgy of Armageddon. A climate change session asks, 'how will we choose to live out the last years of the Holocene and mark its passing?' Read on and commemoration begins to sound suspiciously like celebration. From biodiversity wipeout to financial crisis with a dollop of climate meltdown, all with a song, poem or workshop celebrating it. We have brought about a 'Capitalist Holocaust' and all the health, nutrition, education, women's rights and choice in our societies don't get a look in.

Aren't they just being brutally honest? Haven't all thoughtful people had their 'what's the point, we're all screwed anyway' moment?

Unfortunately the Dark Mountain message is playing right into a nascent and incredibly dangerous public narrative. The term 'pro climate change' is now showing 36,100 results in Google. Pro-climate change scientists are 'tricking' the data, pro-climate change liberals are manipulating the media, and pro-climate change spin doctors are in government.

If we're not careful environmentalists and climate change will end up 'on the same side'. We are becoming climate change's cheerleaders, we're so desperate for people to realise the

magnitude of the looming threat that we begin to sound like fans. This narrative eats away at public trust, and can exile us to the problem side of the debate, rather than the solution.

But by implying we might actually want collapse, we strip ourselves entirely of the right to help prevent it. I'm sure the Dark Mountain founders didn't intend their 'brutal honesty' to play into this narrative. But self-flagellation always has a suspicious air of gratification about it.

An outcome of inaction

When a previously unimaginable threat looms there are always those prophesying the end of the world. And also always a few recommending hard work and a vision of a better future. Dark Mountain isn't a prophesy: it's the outcome of inaction.

I can't help wondering how Dark Mountain's philosophy would be taken in idealistic and progress-orientated countries like Brazil, China and India? They are facing the threat soonest and hardest, but President Mohamed Nasheed of the Maldives is hopefully representative of their response when he compares being a political prisoner with the climate fight: 'I could have lost my life if I'd given it up. By simply believing in life you can get out of situations. I believe in human ingenuity. We are not doomed. We can succeed and we must work along those lines.'

Yes, we've got the fight of our lives ahead of us. On that I utterly and entirely agree. But must we not fight utterly and entirely against that destructive change? Get down off that gloomy mountain and get to work.

'But what about the End of the Universe? We'll miss the big moment.' 'I've seen it,' said Zaphod, 'it's rubbish, come on, let's get zappy.'

Solitaire Townsend is co-founder of sustainability consultancy Futerra. She is also a member of the United Nations Sustainable Lifestyles Taskforce

