Opportunities for decentralised wastewater treatment and review of Skylytix ™ technology for its potential as a sanitation solution for developing countries

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ABSTRACT

Decentralised enhanced watersan solutions have been largely viewed as inappropriate, unworkable and relatively costly for developing countries. They have not been viewed as a viable option for low cost sustainable potable water supplies and/or sanitation solutions. Low cost, high quality sanitation outcomes are now urgent in the context of the MDG goals (1).

Recent advancements and innovations in "enabling" technologies" based on biominicy principles has lead to the migration of "new" treatment systems in the developing world. A new proposed treatment, Skylytix™, is a combination of two recent innovative technologies. It is a decentralised concept that combines the world acclaimed Biolytix® wastewater treatment system with low cost UF membranes to produce a safe effluent. Perhaps with value engineering it could be adopted for developing world applications

The emergence of "decentralised" solutions is challenging our established views of how to solve the global potable water and sanitation issue. The issues are complex and technology utilising low GHG consumption principles are worthy of critical evaluation, however, they are not a "magic bullet" solution.

WHY DECENTRALISED SANITATION SOLUTIONS

Developing countries are still lagging on MDG sanitation targets. Affordable sanitation solutions, as well as high quality potable water at a relatively low cost, will require a new "paradigm". We should consider the merits of distributed and decentralised sanitation alternatives. This is a particularly urgent issue in the context of emerging cities and major peri urban population growth.

It is time to embrace appropriate technology developments from developed countries. We should be not being quick to discard the obvious economies of "centralised wastewater solutions both from a cost and public hygiene perspective. However, significant capital cost and funding delays often mean that communities desperately need short term and immediate solutions.

Decentralised and small scale systems are a mature technology. On site aerobic and anaerobic treatment is well understood in urban environments of developed countries. Clustered systems based on common effluent drainage principles are adopted for remote communities. The issues most often are not treatment quality outcomes but rather amortised cost per allotment and whole-of-life (WOL) operating costs. Translating the "cost" of these systems for application into developing countries is not easy.

It is also essential to include maintenance inspection and regular accreditation or validation costs. This WOL cost must be fairly evaluated in the context of what is affordable for developing countries. Overall, there are challenges if we want to translate these proven solutions is a cost effective and responsible manner.

Decentralised "cluster" or "Biowater" systems are best deployed in peri urban environments. The concept of a "Biowater" design essentially adopts a common effluent drainage design (CED). CED principles should be energy neutral if possible. The challenge for emerging cities will be the design dense multi story peri urban systems using locally available materials

Example of Biowater® "cluster" with onsite treatment

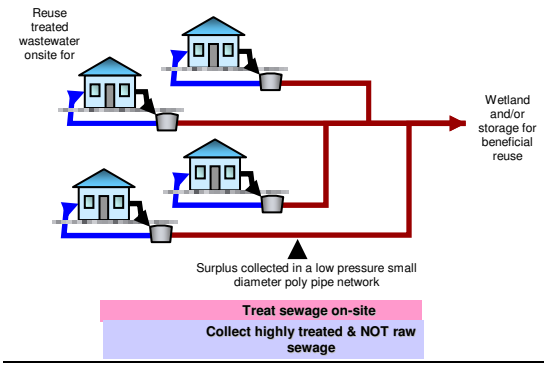

Figure 1: Concept design layout for an existing urban CED "Biowater" decentralised system

WHY NEW "DELIVERY" APPROACHES ARE NEEDED IN CONTEXT OF MDG TARGETS

This paper highlights the concept of a Skylytix™ sanitation system in the developing world context. There are many worthy sanitation and potable outcomes solutions that are candidates for community based (decentralised) sanitation solutions. That is, the combination of two

existing independent technologies to produce an integrated design.

It is absolutely certain that a new "delivery" paradigm will be required to achieve the Millennium Development sanitation Goals and provide affordable sanitation to 2.6 billion existing people and meet additional targets by 2015 [2]. Sanitation systems that couple simple anaerobic treatment with say UF membranes add a new "value" dimension to what is historically a wastewater "issue" .We could also potentially harness a valuable resource in the by-products.

The proposition is that high quality, affordable decentralised water solutions that utilises new technologies, such as membrane technology and other innovations should be seriously considered by major health and humanitarian agencies. There is no simple formula to meet the MDG's. Indications are that there will be a significant shortfall in the MDG target numbers of at least 600 million people [3]. *(See Figure 2)*

It may well be feasible to engage these communities directly in the ownership and operations of essential infrastructure (at a modest level) until medium & longer term network solutions are feasible and affordable. In Africa less than 20 % of the population is connected to sewer, and in Asia it is marginally above 40% of the population [4]

Decentralised or small systems for potable water solutions are not new. How do we accelerate their uptake in stressed communities? More importantly will this approach address the more pressing issues of sanitation, which far the more significant and costly issue.

Concurrently, we also need to address the 4000 preventable deaths [5] every day. A critical assessment of the UNDP "benchmark sustainability criteria" warrant further independent evaluation of the technology based decentralised options.

SANITATION SOLUTIONS ARE URGENTLY NEEDED FOR BASE OF THE PYRAMID (BOP) COMMUNITIES

Four billion low-income people, a majority of the world's population, constitute the "base of the economic pyramid". New empirical measures [6] of their behaviour as consumers as well as aggregate purchasing power suggest significant opportunities for market-based solutions. These must not only address their basic needs for sanitation and water and but meet their aspirational requirements. It is only a matter of time before we see private sector "mechanisms" address this unmet demand.

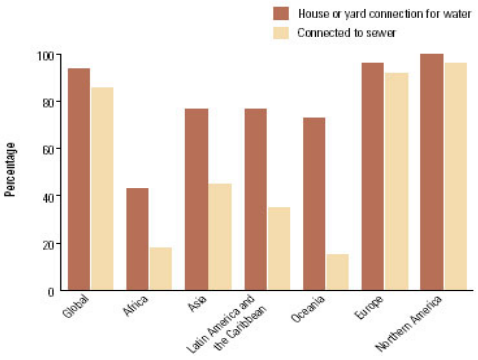

Figure 2: The proportion of households in major cities connected to piped water and sewers

Source: WHO/UNICEF, 2000. *Global Water Supply and Sanitation Assessment, 2000 Report*. Geneva.

Rapid urbanisation of developing countries (such as China, India and others) is increasing stress on networks. Most countries are not capable of funding or financing the huge public sector capital expenditures. Informal and unregulated network providers and vendors are meeting that demand. In most cases there are no regulations, standards are poor and water is potentially unsafe. In many cases they provide the only viable supply option.

It is imperative that we seriously consider alternatives to these centralised networks. Decentralised sanitation is the only "logical" choice. New paradigms are required that remove the huge capital cost burden, inject flexibility in service and supply. Commonly where BOP communities lack access to municipal water supply networks, point-of-use water purification and small-scale community-based water purification and waste treatment can be useful solutions.

Small-scale sanitation networks are the only option in peri-urban communities where serviced currently do not exist. We are evidencing improved point-of-use potable systems being devised and marketed by the private sector. Perhaps decentralised "partnered projects" will begin to show promise for better wastewater options especially in peri urban areas. New models of community engagement and public-private partnership are emerging.

CENTRALISED VS DECENTRALISED SANITATION SOLUTIONS - AN OVERVIEW

There are many possible options to address the wider global issue. Clearly, the issue is much broader than simply treatment and technology options. However, a cost effective and robust set of technology options is essential. Traditional centralised networks and treatment philosophies have served us well. Capital cost is major structural issue for developing countries.

Let's examine the benefits of centralised sanitation solutions and why they have served us well;

ADVANTAGES

- Controlled and regulated CAPEX expenditure.
- High level of public safety and integrity.
- Uniform service outcomes for all.
- Regulated collection and "hygienic"
- Funding and CAPEX well "understood"
- "defined" discharge and disposal points
- Lends itself to economies of large scale treatment technology

There are disadvantages of these traditional paradigm solutions. They typically can be;

DISADVANTAGES

- Delays in donor funding and access to donor funds, donor obligations.
- A potential nutrient rich resource is discarded (usually into an obvious waterway)
- Allocations of treatment cost vs. pipes i.e., 80/20 % expenditure split
- Lengthy period for approval, construction and commissioning.
- Most solutions are site specific and application specific.
- Allocation of headworks/connection fees and ongoing cost and consumption fees
- Treatment standard does not encourage "reuse"

A network approach based on multiple nodes starting at the end of existing networks is already a common occurrence. For decentralised water systems access to a relatively secure source is a major priority.

WHAT ARE THE OPPORTUNITIES FOR DECENTRALISED SANTIATION

There is no disagreement that sanitation issues pose significant MDG obstacles. There are many options. This paper can only highlight some novel approaches and possibilities for cost reduction (affordability).

The best candidates amongst many for small community solutions and micro clusters are;

- Anaerobic CED
- Anaerobic CED + membrane
- CED Biolytix® system
- CED Biolytix® plus membrane
- Low energy MBR

AN OVERVIEW OF BIOLYTIX® TECHNOLOGY

The Biolytix® treatment system is proprietary patented technology of Biolytix® Limited. It was invented by Dean Cameron and has won many international awards. It treats all household sewage and grey water ready for re-use as garden irrigation.

A typical "residential" size Biolytix® is contained in a single, compact tank which is a 3000 litre polymer tank (1.88m diameter by 2.06m high). It is compact making it easier to transport, less disruptive to install and unobtrusive.

Relative to alternatives, a Sand Filter (with its septic first stage) has a footprint approximately 10 times larger than an equivalent Biolytix® design. It is which is 2.8 square metres, whereas a Sand Filter occupies around 26 square metres of space

Inside the Biolytix®, the layered aerobic filter bed is configured to house the organisms that quickly convert sewage into humus. Macro-organisms such as worms and beetles ensure the filter bed is naturally aerated, so that there is none of the smell associated with septic systems, and emissions of methane are negligible.

The ecosystem enables the humus to be maintained indefinitely, so the system only needs one annual check-up (most other sewage systems require up to 3- 4 services per year).

The last layer in the multi layer configuration is an 80 micron geofabric layer, which removes fine solids and is continually biologically cleansed. The treated effluent from a standard system will meet a min 10/10 standard (closer to 5/5). With a UF membrane option treated quality is closer 5/1/. It will normally meet a Class A+ standard

A small air pump is used for ventilation. It consumes 0.12 kWh per day. It ensures aeration of the treated water collected at the bottom of the filter. This is very low compared to the energy usage of conventional aerated treatment systems. Most aerobic system aerators typically consume between 2.5 to 10 kWh per day for treatment only (that is 20-80 times more energy). They can also be noisy producing a background droning noise up to 16 hours per day. (See figure 3)

An Irrigation Pump - safely concealed inside the tank. The single-phase industrial strength pump, pumps the cleansed water to the irrigation field. This pump is cleverly engineered within in the middle of the Biolytix®, which means the tank dampens any pumping noise, resulting in quiet operation.

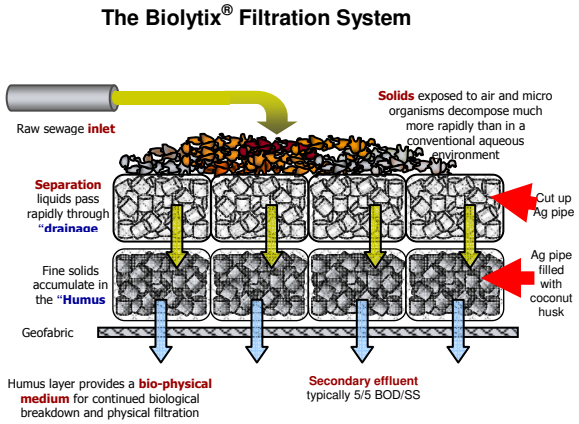

Figure 3: Typical Biolytix® system

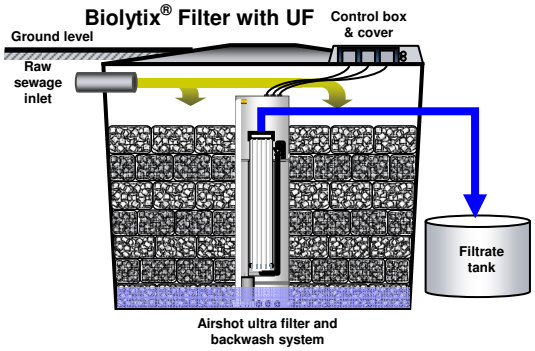

Figure 4: Biolytix® +UF system design for Class A+ recycled water

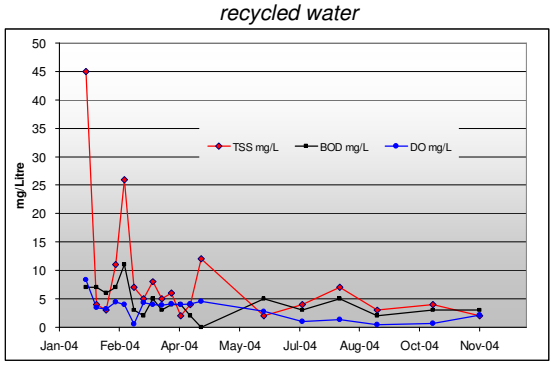

Figure 5: Treated effluent quality from a standard Biolytix® installed at Macleay Island, NSW, and Australia.

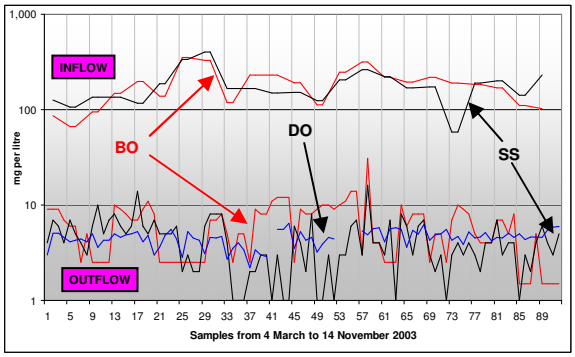

Figure 6: Data from System Accreditation over 8 months (Biolytix® Filter without the UF membrane)

WHAT ARE THE DRIVERS FOR "SMALL COMMUNITY" AND DECENTRALISED SANITATION SOLUTIONS?

Adequately managed decentralised (onsite & cluster) systems are cost effective (USEPA).We need to apply value engineering to source components from local supplies. It is Interesting to note that Chinese authorities say there is insufficient fresh water in China to support the western "flush & forget" infrastructure. It is clear that a major bottleneck will be peri-urban environments in India, China and Africa. We need to address high density cluster systems sooner rather than later.

Anaerobic systems or Biolytix® with a UF membrane "add-on" (Skylytix ™) opens up some interesting ways we "design" solutions for developing countries. More importantly, can we use the by-products as a resource? The Biolytix® + UF system has some compelling features to consider:

- A multiple barrier technology (screening, biological treatment and media plus membrane filtration). Expected to treat to equal or better than Title 22 without chlorine.

- Allows the dwelling owner to recycle water for non potable uses. In multi –level peri-urban precincts surplus treated water can be collected via small bore low pressure pipe network and redistributed within local environs.

- Whole of life cost can be up to half the cost of conventional sewage infrastructure.

- These systems can typically consume 1/10th the power of conventional onsite systems and 1/2 power of large scale reticulated systems

- No chemicals and only annual service required to maintain system operations.

- Can be retrofitted into existing septic tanks and structures.

- The system "devours" kitchen and putrescible waste. It is greenhouse gas neutral and robust with respect to normal household chemicals and prolonged non use.

STRATEGIC INFRASTRUCTURE CONSIDERATIONS FOR SMALL NETWORKS

- They take the cost out of non value adding transport (i.e. dead assets) and put it into treatment solutions.
- The quality and reliability of the treated water allows it to be used for all non potable applications (potentially a 50% reduction in potable demand) with significant impact on water infrastructure and headworks.

- Can divert kitchen waste from landfill at no extra cost. I.e., creates a tangible resource

ECONOMIC & ENVIRONMENTAL CONSIDERATIONS

- Anaerobic + UF or Biolytix® + UF can typically have lower capital and operating cost than current onsite and conventional reticulated infrastructure
- Dramatically reduces water and power use.
- Treats and reuses water at source with reduced pressure on local catchment management.
- Cost saving in diverting kitchen waste from landfill plus the societal benefit from reduced GHG generation (in landfills and from anaerobic sewage treatment) is $A100 per year per household.
- Outcomes can be managed. Implemented and financed on a case by case basis whereby they are tailored to specific site needs. The local community say, 500-5000 persons takes ownership and responsibility for their welfare.

Decentralised cluster systems are best deployed in periurban environments. The concept of a "Biowater" design essentially adopts a common effluent drainage design (CED). CED principles should be energy neutral if possible.

Therefore, it is unlikely that Aerobic systems would be affordable. A brief schematic overview of the Biolytix® process as well as the +UF Membrane concept is shown in Figure 4. Typical operating results for a standard Biolytix® process in shown in figures 5 and 6.

CONCLUSIONS AND OPPORTUNITIES

In summary, we are witnessing advancements and innovations in "enabling" technologies". This has lead to a plethora on "new" treatment systems in the developing world. The emergence of Small Water Enterprises (SWE's) is now common. Their might be an option similar kiosk style installations for sanitation.

Cost comparisons and translation from proven established "developed" world experience will be challenges for a peri urban concept. Safe affordable potable water at realistic volumes is now technically feasible via SWE's but we urgently need to consider the following compelling drivers for small decentralised sanitation:

- 80% of the capital and most of the operating cost of centralised water and sanitation systems is invested in pipes, pumping and their service as distinct from treatment - transport is a non value adding investment
- There is no economies of scale in large versus small reticulated systems
  - The lower treatment cost/capita for large systems offset by the higher cost of collection (i.e. pipes).
  - Large centralised systems require significant capital and operating cost for pump stations and odour control.
- Large centralised networks and systems are not environmentally sustainable;
  - They are wasteful. Most developing countries there are insufficient water for western "flush and forget" solutions.
  - They take water from where it could be used beneficially to where it usually cannot and create a major disposal task in the process.
- New urban developments require large upfront infrastructure costs – onsite treatment is incremental
- The funding is simply not available or in place to meet MDG's using large capital intensive centralised solutions
- They also delay potential urban development due to multi donor facilitation and long term funding commitments.
- We must consider that collecting and treating sewage in an aqueous environment generates about 70 kg/person of greenhouse gas equivalents per year.
- Centralised systems discourage individual environmental responsibility – convenient but easy to "flush it down the toilet".

Currently new players are entering the number of water kiosk projects, mobile water vendors and community based water systems. Each has a common theme being "decentralised treatment" of "kiosk solutions". Community based water vendors and entrepreneurs are viable. Are sanitation models appropriate?

The sanitation solution model is more complex than treatment and most involve a multi level commitment that includes validation and testing and hygiene reinforcement. The need is urgent. Partnerships between private and public sector organisations are essential. Demonstration projects that involve joint stakeholders are needed. New technologies and solution models should be critically examined under real conditions.

The opportunities for new paradigm solutions make for a compelling economic supposition. That assertion is that the Millennium Development Goals should be affordable and decentralised systems are practical. There are no unique sanitation technology solutions.

These recent cluster solutions water solutions and kiosk concepts (SWE's) essentially mean we have no reason to ignore the "possibility" of workable sustainable sanitation for all citizens of the world. These may just be the critical affordable technologies to assist developing nations to meet the multi facet objective of sanitation and resource management in a realistic and pragmatic manner.

Base of the pyramid consumers for water, energy and mobility will require cost effective and robust solutions. Those customers exist. A global ethical initiative to service our fellow citizens and provide them with basic dignity must surely rate as and immediate and overdue obligation. Now is the time to act. Technology is only part of the answer.

Note: The Skyjuice Foundation is a registered, independent non-profit incorporated charity based in Australia. It is NOT a commercial organization.

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