Looking beyond centralised delivery paradigms by utilising technology solutions and innovative strategies to achieve enhanced U.N. MDG outcomes

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ABSTRACT

Traditional development assistance has largely focussed on centralised donor funded treatment schemes. For various reasons decentralised solutions have been viewed as “inappropriate” and relatively costly. They have not been viewed as a viable option for low cost sustainable potable water supplies and/or sanitation solutions.

Recent advancements and innovations in “enabling” technologies” based on biominicy principles has lead to a plethora on “new” treatment systems in the developing world. Cost implications are promising. Safe affordable potable water at realistic volumes is now technically feasible.

The emergence of legitimate Water Kiosks and Small Water Enterprises (SWE’s) based on “decentralised” solutions are challenging our established views of how to solve the global potable water and sanitation issue. The issues are complex and technology is not a “magic bullet” solution.

WHY DECENTRALISED 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 water supply and sanitation alternatives.

It is time to critically examine if sustainable non centralised solutions, which embrace technology developments from developed countries. The combination micro entrepreneurs and novel financing mechanisms can seriously address the entrenched issue of global affordable water supply. The emergence of SWE’s and community kiosks is evidence that needs are not being adequately met. These concepts and solutions are reviewed and briefly discussed.

We should be not being quick to discard the obvious economies of “centralised water and/ or 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.

WHY NEW “DELIVERY” APPROACHES ARE NEEDED IN CONTEXT OF MDG TARGETS

This paper overviews the validity of a decentralised option for “suitable” applications. Viable sanitation and potable water outcomes may well involve a solution that incorporates some level of private sector funding. Additionally, community equity participation for community based potable water solutions is preferable prerequisite to ensure long term success..

It is absolutely certain that a new “delivery” paradigm will be required to achieve the Millennium Development Goals and provide safe affordable water to 1.1 billion people by 2015 (1). The Asian tsunami response during early 2005 was a catalyst that resulted in new innovations, solutions and decentralised solutions being tested and evaluated.

For example, technologies such low pressure membrane systems and UV disinfection have traditionally not been considered affordable or sustainable for emerging communities. Recent nodal water kiosk projects, such as SWE’s and other community based derivatives, have embraced these technologies. Sanitation systems combining and coupling simple anaerobic treatment with say UF membranes add a new “value” dimension to what is historically has been a wastewater “issue” by potentially harnessing a nutrient resource.

With recent United Nations initiatives in place to accelerate access to pure affordable water (2), the results of various water kiosk projects and installations have challenged conventional cost and delivery assumptions. Should funds be expended in treatment or distribution networks?

The proposition is that high quality, affordable decentralised water solutions that utilise these newer 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 210 million people (3).

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?.It is time to think outside the box and embark on bold initiatives?. Concurrently, we also need to address the 4000 preventable deaths(4) every day. A critical assessment of the UNDP "benchmark sustainability criteria" coupled with real costs of $1-10 per person per annum warrant further independent evaluation of the these technology based decentralised options.

It may well be feasible to engage these communities directly in the ownership and operations of essential infrastructure (at a modest level) until medium and longer term network solutions are feasible and affordable.

CENTRALISED SOLUTIONS ARE NOT ALWAYS AFFORDABLE 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 (5) of their behaviour as consumers and their aggregate purchasing power suggest significant opportunities for market-based solutions that 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.

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 regulations are not enforced or met, standards are poor and water is potentially unsafe. In many cases they provide the only viable supply option.

It is imperative that we at least seriously consider alternatives to these centralised networks. Decentralised water and sanitation is the only "logical" choice. New paradigms are required that remove the huge capital cost burden, inject flexibility in service and supply.

There is a widely held view that the BOP suffers a significant penalty in access to safe drinking water. World Bank (World Resources Institute) Household survey data confirms this view. In 9 of the 29 countries for which sufficient data exist For a comparison, the ratio of mid-market households to BOP households with access to piped water is 6:1 or higher. I.e., the poor have less opportunity to access safe water.

Also access to public standpipes reflects a similar pattern—significantly lowers access in the BOP than in the mid market. While BOP households are more likely to use surface water and less likely to have access to piped water, a third alternative, especially in peri-urban areas, is to buy from mobile water vendors. This option typically involves a significant price penalty. One study showed that in eight major cities water vendors charge prices 8–16 times those charged by public utilities (3) (UNDP 2005). Another study, covering 47 countries, found that Mobile distributors such as tanker trucks charge unit prices up 10 times the price of piped water.

Commonly where BOP communities lack access to municipal water supply networks, point-of-use water purification and small-scale community-based water purification (probably micro-financed) and waste treatment can be useful solutions. There are community based approaches and innovative programs. One, for example in Orangi, an informal settlement area in Karachi. Pakistan services 1.2 million people.

Left to their own devices people will obtain water in many ways (usually from suspect sources). Some collect it at no "cost" (apart from the considerable cost of their labour) from streams or other surface sources or from wells or community standpipes. Others must pay for it. But households in Africa and Asia will also purchase water from vendors and small-scale community water systems and pay for point-of-use services as required.

The private sector is often the provider of last resort. Small-scale water vendors are often the only option in peri-urban communities. Improved point-of-use systems being devised and marketed by the private sector also show promise for giving BOP households better options for water supply, especially in rural areas. New models of community engagement and public-private partnership are emerging.

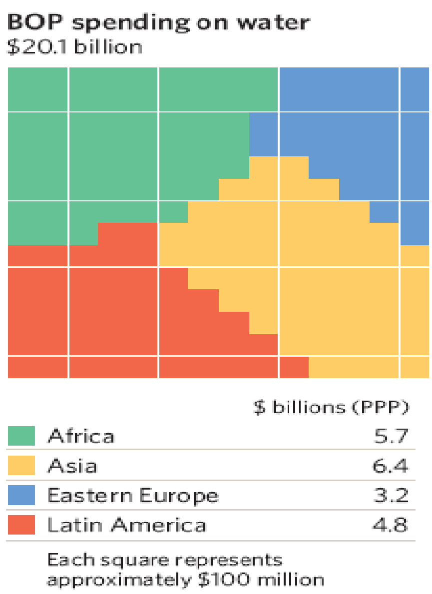

Figure 1: Estimate of BOP spending on water
Source: World Resources Institute Paper: 2006

CENTRALISED 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 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 supply and "hygienic"
- Revenue stream can be captured the assist with ongoing operations.
- "trusted" outputs and delivered free
- Lends itself to government(utility) control regulation and management.

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

DISADVANTAGES

- Delays in donor funding and access to donor funds, donor obligations.
- Ability of user to pay and collection of revenue from customer base.
- 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
- Vandalism, Water theft and operability.

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 not always assured so it is a major priority for site selection.

Unregulated water sources, marginal sources or seasonal sources affected by external factors will always be an issue.

WHAT ARE THE DRIVERS FOR DECENTRALISED NETWORKS ?

Funding issues are the main drivers forcing the case for small solutions. Sewage and sanitation will always be difficult issues because of the discharge requirements. Potable water solutions have recently been more formalised with the emergence of water kiosks. Microfinanced solution/ enterprises and micro entrepreneur financed models. These are still typically niche solutions gaining increasing popularity and interest.

They would typically revolve round a "point of use" collection model where customers collect water in designated containers rather than distribution through micro networks.

These micro providers or small water enterprises tailor solutions to geographic and demographic requirements. In most cases there is a private sector and risk capital component.

Publically funded solutions are not wide spread. Certainly a lack of existing service or infrastructure is the main driver. Successful organisations active (amongst many) are;

- Water Partners
- Water Health International
- Osram
- Solco International
- Asia Water Foundation

Revenue stream is usually captured by the sale of a "metered volume" typically 20 litres. Pricing per litre will vary greatly and there is no general rule. SWE's are dynamic should continue to flourish as micro finance enterprises continue to gain broader acceptance.

TECHNOLOGY EVALUATION

When assessing potable water needs then water kiosks and decentralised plants will almost certainly need a multiple stage design to address all the relevant source water contaminants. We know that many regions of Africa and India, as an example, will require TDS reduction due to elevated salt concentrations, fluoride and other dissolved species present in the feedwater.

These applications will require a multi –stage process treatment solution. Reverse Osmosis is an obvious candidate technology, but it is not without issues (brine production, energy consumption and maintenance to name a few)

Systems based on a robust design that can be duplicated in multiple locations will most likely deliver long term results. Sustainability in terms of energy consumption and chemicals is imperative. Whole of life cost (WOL) will be heavily influenced by operations consumables.

Decentralised community based plants that inefficiently consume energy, media, flocculants, etc cannot be long term viable options. Solutions that adopt biominicy and natural physio/chemical methods will prevail. Best technology “outcome” options for potable treatment that represent minimal environmental impact are as follows:

Technology Options	*Poor*	*Aver*	*Good*	*Exc*
Sand filtration	X			
Multimedia Filtration		X		
UV lamp			X	
Natural UV sunlight		X		
Ceramic membranes				X
Low pressure membrane				X
Ion exchange	X			
Reverse osmosis	X			
Coarse cartridge filter	X			
Fine cartridge filter	X			
Carbon filter/bed	X			
Flocculation/coagulation	X			
MIOX			X	
Chlorination			X	
Coarse screening	X			
Natural Zeolytes	X			
Biosand filter		X		

Figure 2: Comparison of potential relative treatment “outcome” technologies for potable water production

The Murdoch University School of Environmental Science (MUSES) undertook an independent three way evaluation of available technologies in 2004. The objective of the assessment by Wendy Green [6] was to verify technology options vs. performance and also determine if which of the options were most environmentally sound to alternative methods. (Laboratory tests over 2 months).

For verification, MUSES undertook laboratory examination of clay and algae turbidity removal as well as bacterial removal on 3 UF units. Control and membrane fault tests were also performed using deionised water and the bubble point test.

The Environmentally Sound Technology – Performance Assessment (EST-PA) was used to assess the amongst many options, UF, chlorine disinfection (by Calcium Hypochlorite) and others The EST-PA was still under development by the United Nations Environment Program. EST-PA proposed criteria and indicators were used with some suggested changes to analyse the technologies.

Murdoch University verified that UF membranes were found to be the most environmentally sound technology and suitable for low virus risk areas, whilst chlorine disinfection could be suitable but had higher environmental impacts.

THE COST, VALUE AND SERVICE PROPOSITION

In the case of potable water kiosks and SWE’s pricing like many commodities, is not primarily determined by the “treatment” cost but rather the overall investment and establishment costs on the facility. The overall project investment amortised for an “installation” can typically be as follows

Item / breakdown	***Cost proportion %***
Land and building	50 - 75
Treatment equipment	10 -20
Consumables/energy	3 - 10
Labour	10 -25
Finance or loans	0 - 25
Local Marketing	0 - 10
Compliance & testing	0 – 5
Sundry costs	0 – 5

Figure 3: Typical proportional cost breakdown for the establishment of “informal” decentralised water kiosks

Small village installations range from as low as US $5000. However, it is not unusual for more substantial installations to cost upwards of USD $100,000. Some systems are supplying 20 litres of “safe” water per day for less than $1 USD PA.

SOME RECENT CASE STUDIES

The case studies presented here are typically small to medium size installations for the provision of potable water. Typical facility size is 100- 1000 persons. Needless to say, the availability of a “safe” or non compromised source is a paramount consideration in the location of the kiosk or SWE.

Also availability of the source water is a major decision factor. Some the typical installations are shown, but by no means comprehensive are;

Figure 4: Water Health International Kiosk Africa: (Image courtesy of Water Partners Kenya)

Figure 5: Low cost "Community Watertower" installation by Asia Water partners in India (cost = 50 cents/per/pa)

Figure 6: Retail water kiosk Kenya (Image courtesy of Pureflow Water Solutions, Kenya)

Figure 7: Low cost community Water Kiosk and vendor located in Kurail slum district of Bangladesh

Figure 8: Solco "Meeru Fen" Water Factory, Maldives Containerised RO plant including delivery service

Many installations use compact high volume membrane water filtration system designed for developing nations (specifically the Millennium Development Goals target No.7 outcomes) and disaster relief applications. The filtration barrier is a micro porous low pressure membrane that removes suspended solids, bacteria, helminths, protozoa such as Giardia, Cryptosporidium, and some viruses. This physical "disinfection" process when combined with optional chlorination (to ensure viruses are killed) produces safe drinking water from the majority of non-saline surface and ground waters.

WHAT ARE THE OPPORTUNITIES FOR DECENTRALISED SANTIATION

Sanitation issues pose the greatest challenge. The case for immediate action on sanitation is no less important than potable water. This is a more protracted problem and not without difficulties. There are many logical treatment 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

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" opens up some interesting ways we "design" solutions for developing countries.

More importantly, can we use the by-products as a resource? A potential 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 say a 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 "cluster" 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 simple CED or cluster design philosophy is shown in Figure 9. Figure 10 and figure 11 give a brief schematic overview of the Biolytix® process (7) as well as the concept of a Bioltyix® + UF membrane design.

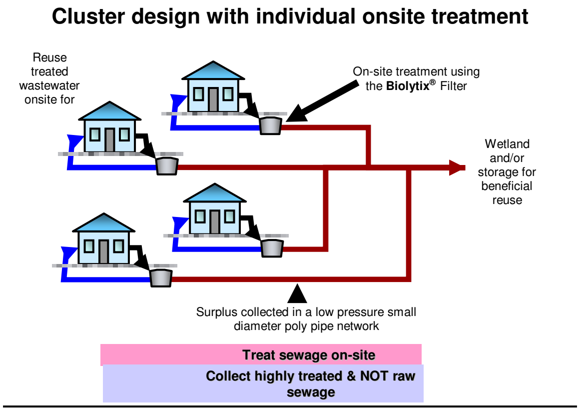

Figure 9: Concept design layout for a "Cluster" decentralised system

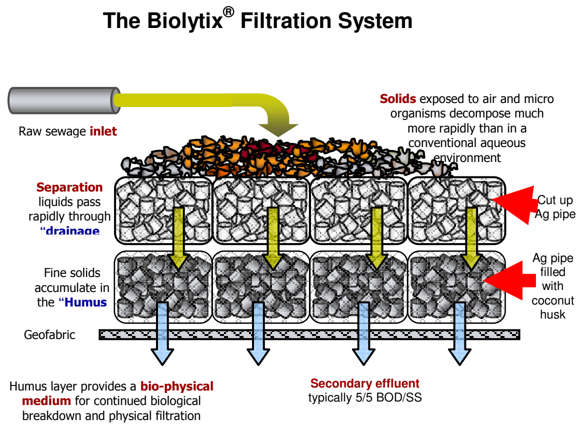

Figure 10: Typical construction of a Biolytix TM system

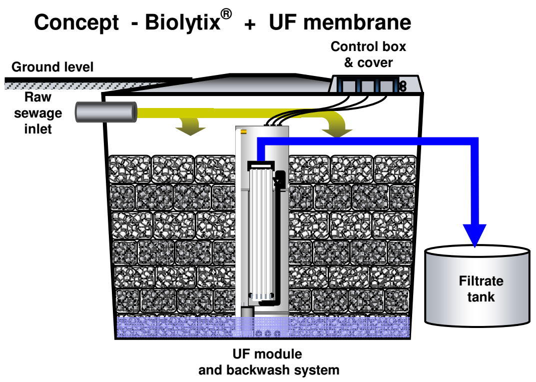

Figure 11: Bioltyix TM +UF system design for Class A+ recycled water

CONCLUSIONS, COSTS AND THE FUTURE

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. Cost implications are promising. Safe affordable potable water at realistic volumes is now technically feasible but economic issues and urgency means we need to consider the following compelling drivers:

- 80% of the capital and most of the operating cost of centralised systems is invested in pipes, pumping and their service as distinct from treatment - transport is often a non value adding investment component.
- 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”.

There is existing low cost potable water cluster solutions that have been developed for immediate disaster deployment as well as medium term requirements. Currently new players are entering the number of water kiosk projects, mobile water vendors, SWE’s and community based water systems. Each has a common theme being “decentralised treatment” of “kiosk solutions”. The most innovative project is probably a mobile water vendor in the Philippines. He visits up to 8 villages each day on his motorcycle, with his Skyhydrant^{TM} attached, treating water locally at each source.

Community based water vendors and entrepreneurs are viable. The solution and model is more complex than treatment and most involve a multi level commitment that includes validation, testing and hygiene reinforcement. The vendors are equally responsible to ensure water is collected in safe, clean containers.

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. Technology a not a magic bullet and certainly where a communal supply based of poor quality water can is the only viable option then an immediate evaluation is warranted.

Kiosk style plants for 3000-5000 people are now reality for less than US$10.00 per person per annum. These decentralised potable water solutions and kiosk concepts essentially means we have no reason to ignore the affordability of pure safe, sustainable water for all citizens of the world. There may just be the critical affordable technologies to assist developing nations to meet the multi facet objective of providing safe pure drinking water 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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