S.A.P.I.EN.S
4.1 (2011)
Vol.4 / n°1

Bruce Beck and Rodrigo Villarroel Walker

Global Water Crisis: A Joined-Up View From The City

Electronic reference
Bruce Beck and Rodrigo Villarroel Walker, « Global Water Crisis: A Joined-Up View From The City », *S.A.P.I.EN.S* [Online], 4.1 | 2011, Online since 27 December 2011, Connection on 22 February 2012. URL : http://sapiens.revues.org/1187

Publisher: Institut Veolia Environnement
http://sapiens.revues.org
http://www.revues.org

Document available online on: http://sapiens.revues.org/1187
This document is a facsimile of the print edition.

INSTITUT
Veolia Environnement

Views

Global Water Crisis: A Joined-Up View from the City

M Bruce Beck & Rodrigo Villarroel Walker

Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia, USA, http://warnell.uga.edu/ and www.cfgnet.org

Correspondence to: mbbeck@uga.edu

Keywords: Entrepreneurship and innovation, resource recovery, urban metabolism, water policy.

TABLE OF CONTENTS

1. INTRODUCTION

We divide the world into parts. And water is such a natural and prominent part of it all. So we have books threatening "When the Rivers Run Dry" (Pearce, 2006) or "The Big Thirst" (Fishman, 2011) and articles in the New Yorker imagining "The Last Drop" (Specter, 2006). This is the "Global Water Crisis" of which we hear so much: our global access to water for drinking and for agriculture, hence our food security, is threatened. The target endpoint of water supply has become the vessel into which oceans of policy thinking are poured. Water, water, everywhere.

2. CITIES: FOCUS OF CHOICE

Yet consider the world again; then the city; and imagine yourself in that city. Increasingly, the city is becoming the eye of the needle through which so much is threaded: water, energy, nutrients; the very stuff of our daily bread and daily water. So much of the demand for whatever is produced in the world comes from the choices we urban dwellers make. It is not choice over water that counts, although we might quibble about its taste–provided it is wholesome in the first place. It is choosing our diets.

Viewed from the city, diet can have profound implications for generating the food we choose to consume. 15 tonnes of water are burned up in producing a kilogram of beef, 3 tonnes for a kilogram of cereal (Mekonnen & Hoekstra, 2010); hence the impact of dietary choices on global water demand. We are entreated to become vegetarians; and not just in the interests of curbing global water demand. Lord Stern (of the Stern Review of the Economics of Climate Change; Stern, 2006) has urged that we eat less meat, because the production of meat is kilogram for kilogram more consumptive of energy, not least through the associated industrial production of fertilizer, at the head of the food chain.

Published: 27 December 2011.
Edited by: Gaëll Mainguy

A good deal of the city's daily water is employed to carry away the residuals of the city's daily bread. We call this wastewater. We process it to be utterly rid of its polluting residuals–the nutritious nitrogen (N) and phosphorus (P) in our food–and put it back into the water environment. For if we are not free of these nutrients, plant matter will grow in water instead of on the land. That would be pollution. It is called eutrophication and can lead to the "red tides" and "dead zones" of the Gulf of Mexico (Mitsch *et al.,* 2001; Elser & Bennett, 2011).

Global trade in foodstuffs is tantamount to extracting nutrients from the soils of exporting countries, only to fuel coastal eutrophication downstream of the cities in food-importing nations.

Where we are fortunate enough, we have city water utilities to take care of the consequences of our consumption and our metabolism. If we did not employ water–and a good deal of it–for flushing our WCs and conveying our wastes (including nutrients) out of our cities, we should not have this kind of water pollution in the first place.

What might be done to recover those valuable nutrient resources is left out of water policy and is at odds with water utilities and watershed management. We have no comparable city nutrient utilities, nor "soilshed" management agencies. How should we think, behave, and form policy, if instead wastewater were called anthropogenic nutrient solution (ANS)? For that–commonly known as urine–is where the N and P concentrate (Larsen *et al.,* 2009).

Water policy is directed (with success) at water pollution control. Impairment of water quality is essentially concerned with freeing the water environment of the impacts of the city's nutritional, metabolic residuals, as well as the residuals of producing our daily bread, back up along the food chain in agriculture. Such policy does not do a good job of sparking nutrient resource recovery.

Should it? Possibly not.

3. ENTREPRENEURSHIP & INNOVATION

Halting eutrophication does not come cheaply these days–at least not for cities. Water policy is already making it very expensive to eliminate nutrients when they are considered as pollutants. Ridding the wastewater of Metro Atlanta, Georgia, of a further 50 tonnes of "polluting" P beyond current performance levels might cost around $0.3-0.5M (as a total annualized economic cost; based on Jiang *et al.,* 2005). These extra 50 tonnes of P per annum would end up unproductively in landfills or building bricks (DPCD, 2008), as does all the P presently so "eliminated". Yet there could be as much as 1,700 tonnes of "resourceful" P to be recovered each year in the city's household sewage, along with 16,600 tonnes of N, with a combined annual market value of $26M as fertilizer. Set against operating and capital works costs, an annual net income of $4M is possible (based on the figures of Dockhorn (2009)), together with savings in operating costs of about $1.2-2.0M from not having to eliminate the recovered P and N as pollutants.[1] Instead of water pollution control being some never-ending, policy-driven drain on the public purse, an entrepreneurial benefit stream could seemingly be conjured up.

Atlanta's peri-urban economy–in the watershed of the Upper Chattahoochee River–boasts a thriving poultry industry. Poultry, pigs, and cattle are reared intensively in Confined Animal Feeding Operations. These CAFOs (the industry phrase) generate ample amounts of residuals from their nutritional metabolism. Widespread introduction of technologies such as poultry litter pyrolysis[2] could enable recovery of a sizeable quantity of fertilizers–900 and 2,100 tonnes per year of N and P fertilizer respectively (valued at $8M on the same basis as above)–not to mention liquid and gas biofuels with an energy value of 250 GWh and worth up to an additional $12M annually.

Perhaps this is not a matter of wielding the stick of policy and regulations, but of the market dangling a carrot–or the mouth-watering prospect of biofuels–in front of some pioneering entrepreneurs. For what are cities, if they are not Confined Human Feeding Operations (CHFOs)? Perish not the thought! Indeed, is there a CHFO entrepreneur in town?

There once was.

4. HISTORY NOT QUITE REPEATING ITSELF

Paris was remarkably successful throughout the 18th and 19th centuries at exploiting the patents filed for making fertilizers out of the residuals of its citizens' daily bread. About 40% of their dietary N was being returned to agriculture in the Parisian surrounds by 1913–"From yesterday's bread unto tomorrow's", as it were (Barles, 2007a,b).

Why did things change? First, progressive popularization from the 1860s/70s onwards of the WC, often credited to the British Mr Crapper, had literally been diluting out the concentrated worth of the residuals. Then, in 1908, Haber and Bosch filed their patent for making ammonia (N) from the nitrogen in the air all around us. This led to the greater production of more effective explosives and arguably, therefore, the First World War (Erisman *et al.,* 2008). Their patent also opened the way for massive artificial fertilizer production, to replenish the soil nutrients otherwise exported away in foodstuffs: hence the impact today of the vast energy-carbon footprint of industrial fertilizer production; hence Lord Stern's urging us all to eat less meat.

It is not that we should not be hugely thankful for the WC and its wet sanitation enabling us to lead healthy and productive economic and social lives in the city. Yet what might have been, had the Reverend Moule's Earth Closet (EC) for dry sani-

1 Mass fluxes based on Villarroel Walker and Beck (2012); market price based on $526 per ton as N-based fertilizer (Urea 46% N) and $633 per ton P-based fertilizer (Super-phosphate, 46% as P_2O_5), as reported by the US Department of Agriculture for March 2011.
2 Pyrolysis is the thermal decomposition in the absence of oxygen of organic compounds, such as biomass, to produce liquids, char or coke, and gas. Detailed information about the process and its products can be found in Das *et al.* (2008) and Ringer *et al.* (2006).

tation won out in the technological innovation stakes of the 19th Century, instead of Mr Crapper's WC? For dry sanitation (EC)–and entrepreneurship–is once again beginning to thrive in the capital of Burkina Faso. "The Emerging Market of Treated Human Excreta in Ouagadougou" heralds the title of a 2010 article of the Urban Agriculture magazine (Dagerskog *et al.,* 2010). Absent the WC and all else, think too how dry sanitation might dampen down the Global Water Crisis.

But why stop there? Anthropogenic Nutrient Solution is perfect for growing micro-algae (the culprits of eutrophication from untreated human sewage); and biofuels can be generated from them (for example, Clarens *et al.,* 2010). There are even CHFO entrepreneurs. One of them went to the December (2010) Cancun Climate Conference seeking venture capital to remove carbon dioxide from the atmosphere to fuel the growth of micro-algae from sewage.[3] We can imagine the banner headline already: "Climate Change Drives Market for Urine-separating Toilets." Such devices exist, are being installed, and one of their products is ANS (Larsen *et al.,* 2009; Elser & Bennett, 2011).

5. Joined-up thinking

Waste-water–both words, joined so, are impediments to joined-up thinking–is the utter embodiment of the joined-up physics and chemistry of our daily bread and water. Our choices over diet, our household plumbing, our water-based urban systems of sanitation, mean that water-nutrients (and energy) are inextricably inter-mingled as they are threaded through the metabolism of the city–and every one of us.

Driven still by water policy for water quality, Thames Water has very expensive plans: to spend some $3B to deal with London's sewer overflows discharging untreated wastewater (nutritious N and P) to the Thames (McCann, 2010). And yet–from market forces asserting themselves underneath the overburden of such water policy–something new about nutrient resource recovery is being expressed. On 29 September, 2010, marketwire.com reported that Thames Water and Ostara Nutrient Recovery Technologies would re-engineer Slough Sewage Treatment Works: "to recover phosphorus and ammonia from its wastewater stream and transform them into an environmentally-friendly, premium-quality commercial fertiliser"[4].

If only more of these multiple strings of multi-sectoral and cross-sectoral entrepreneurship and innovation were pulled together from this city-centric outlook on the world–instead of just the single-stringed, universally water-focused, global policy perspective–how greatly might things then change.

We all try to grab the headlines. Non-water specialists do their bit for their focal interests. For some, the 21st Century will be a "Nitrogen Economy" (Erisman *et al.,* 2008). For others it will be the Century in which "Peak Phosphorus" will render "Peak Oil" a mere bump in the global economic super-highway (Elser & Bennett, 2011). It might even be the Century in which we write a book with the title "When The Soils Do Not Starve". This might break some of the mold of the fixation on water alone. Yet it would be to fall into the same trap of championing but a single strand of thinking–of being every bit as disjointed.

Countering what we argue to be the weaknesses today of the historical hegemony of water-centric policy should not be achieved by establishing any future countervailing N-centric, P-centric, or carbon-centric policy hegemony. Yes, becoming less unsustainable should be desirous of policy and incentives of a more rounded, multi-faceted nature. But if the requisite innovations, be they technological, social, or otherwise, can be sparked in spite of the administrative compartmentalization of governmental agencies and regulations, so much the better. We wonder, however–after decades of water technologies for the water industry, nitrogen technologies for the nitrogen economy, and so on–whether the "locked-in" socio-economic structure of the market is ready to hear the cries of the CHFO entrepreneur banging on its closed doors from the outside (Beck, 2011).

References

Barles, S. (2007a). Feeding the city: food consumption and flow of nitrogen, Paris, 1801-1914. *Science of the Total Environment* 375: 48-58.

Barles, S. (2007b). Urban metabolism and river systems: an historical perspective–Paris and the Seine, 1790-1970. *Hydrology and Earth System Sciences* 11: 1757-1769.

Beck, M. B. (2011). *Cities as Forces for Good in the Environment: Sustainability in the Water Sector*. Athens: Warnell School of Forestry & Natural Resources, University of Georgia (ISBN: 978-1-61584-248-4) (also available from www.cfgnet.org).

Clarens, A. F., E. P. Resurreccion, M. A. White & L. M. Colosi (2010). Environmental life cycle comparison of algae to other bioenergy feedstocks. *Environmental Science & Technology* 44: 1813-1819.

Dagerskog, L., C. Coulibaly & I. Ouandaoga (2010). The emerging market of treated human excreta in Ouagadougou. *Urban Agriculture Magazine* 23: 45-48 [posted at www.ruaf.org].

Das, K. C., M. Garcia-Perez, B. Bibens & N. Melear (2008). Slow pyrolysis of poultry litter and pine woody biomass: impact of chars and bio-oils on microbial growth. *J Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering* 43: 714-724.

3 The broad view is that, although oil from algae is currently more expensive to produce than the fossil fuel itself, greenhouse gas mitigation costs may yet make this renewable fuel potentially competitive (Li *et al.,* 2008; Kovacevic & Wesseler, 2010; Fischer *et al.,* 2011). In particular, this competitiveness will be enhanced where algae production can be coupled jointly with power plant exhausts and a wastewater treatment facility.

4 www.marketwire.com; accessed 13 April, 2011.

Dockhorn, T. (2009). About the economy of phosphorus recovery. In K. Ashley, D. Mavinic and F. Koch (Eds.) *International Conference on Nutrient Recovery from Wastewater Streams* (145-158). London: IWA Publishing. ISBN: 9781843392323.

DPCD (2008). *Atlanta Strategic Action: your city, your vision, your plan.* Department of Planning and Community Development (DPCD), City of Atlanta, Bureau of Planning. Available online http://www.atlantaga.gov/government/planning/asap.aspx (last accessed January, 2012).

Elser, J. & E. Bennett (2011). Phosphorus cycle: A broken biogeochemical cycle. *Nature* 478: 29-31.

Erisman, J. W., M. A. Sutton, J. Galloway, Z. Klimont & W. Winiwarter (2008). How a century of ammonia synthesis changed the world. *Nature Geoscience* 1: 636-639.

Fischer, B. L., J. W. Richardson, J. L. Outlaw & M. S. Allison (2011, February). *Economic feasibility of commercial algae oil production in the United States*. Paper presented at Southern Agricultural Economics Association: 2011 Annual Meeting, February 5-8, 2011, Corpus Christi, Texas, USA.

Fishman, C. (2011). *The Big Thirst. The Secret Life and Turbulent Future of Water.* New York: Free Press.

Jiang, F., M. B. Beck, R. G. Cummings, K. Rowles & D. Russell (2005). Estimation of costs of phosphorus removal in wastewater treatment facilities: adaptation of existing facilities. *Water Policy Working Paper* # 2005-011, Andrew Young School of Policy Studies, Georgia State University, Atlanta, Georgia.

Kovacevic, V. & J. Wesseler (2010). Cost-effectiveness analysis of algae energy production in the EU. *Energy Policy* 38(10): 5749-5757. (doi: 10.1016/j.enpol.2010.05.025)

Larsen, T. A., A. C. Alder, R. I. L. Eggen, M. Maurer & J. Lienert (2009). Source separation: will we see a paradigm shift in wastewater handling? *Environmental Science & Technology* 43(16): 6121-6125.

Li, Y., M. Horsman, N. Wu, C. Q. Lan & N. Dubois-Calero (2008). Biofuels from microalgae. *Biotechnology Progress* 24(4): 815-820.

McCann, W. (2010). Poised for planning: the Thames Tideway tunnel. *Water21* (August): 56-58.

Mekonnen, M. M. & A. Y. Hoekstra (2010). *The green, blue and grey water footprint of farm animals and animal products. Volume 1: Main Report.* Value of Water Research Report Series No. 48. Delft, the Netherlands: UNESCO-IHE Institute for Water.

Mitsch, W. J., J. W. Day Jr., J. W. Gilliam, P. M. Groffman, D. L. Hey, G. W. Randall & N. Wang (2001). Reducing nitrogen loading to the Gulf of Mexico from the Mississippi River basin: strategies to counter a persistent ecological problem. *BioScience* 51(5): 373-388.

Pearce, F. (2006). *When the Rivers Run Dry: Water–The Defining Crisis of the Twenty-first Century*. Boston, Massachusetts: Beacon.

Ringer, M., V. Putsche & J. Scahill (2006, November). *Large-scale pyrolysis oil production: a technology assessment and economic analysis.* Technical Report (NREL/TP-510-37779). Golden, Colorado: National Renewable Energy Laboratory (NREL).

Specter, M. (2006). The last drop. *The New Yorker* (23 October): 60-71.

Stern, N. (2006). *Stern Review on the Economics of Climate Change*. HM Treasury, UK Government (ISBN : 0-521-70080-9).

Villarroel Walker, R. & M.B. Beck (2012). Understanding the metabolism of urban-rural ecosystems: a multi-sectoral systems analysis. *Urban Ecosystems* (in revision).