The Green Economy

Greening the economy is a crucial process if countries want to improve human wellbeing and social equity while reducing environmental dangers and ecological shortages. UCT research across many disciplines is breaking new ground and helping to speed up the transition.

At UCT, a number of researchers across the university are engaged in various inter- and multidisciplinary research projects, with the aim of contributing substantially to a greener economy, and thereby improving the well-being of all South Africans. A number of these projects extend into Africa, broadening the reach and increasing the impact. The research being undertaken in the Faculties of Science and Engineering & the Built Environment has been particularly ground-breaking, and promises to make fundamental contributions to this area, and to inspire and train the next generation of scholars.

Clean technology and cleaner production have been research themes in UCT's Department of Chemical Engineering since the time of the 1992 Earth Summit in Rio de Janeiro. Initially viewed as newcomers to academic research, such themes have steadily gained in importance as the magnitude of local and global environmental degradation became clearer. The 2011 'Green Economy' report of the United Nations Environment Programme (UNEP) signalled a new globally concerted effort to address the Millennium Development Goal 7 (ensuring environmental sustainability). This concept of a green economy was readily taken up in South Africa, to realise its economic development potential. Green economy desks or programmes have since been established in national, provincial and many local governments.

But is more research needed? Is it not enough to simply deploy tried and tested wind turbines and photovoltaics so as to start greening South Africa's electricity supply?

The large-scale use of renewable energy for electricity generation undoubtedly is a necessary condition for sustainable development. In this regard, the recent global green economy push is making significant gains on earlier programmes. But, according to UCT researchers, a programme only focused on green energy is unlikely to be sufficient, as it does not link strongly enough to development concerns, or address environmental problems related to the material rather than the energetic dimension of our consumption-based economy.

Globally, this material dimension of sustainable development has been receiving concerted new attention through the work of the International Resource Panel established by UNEP in 2011. UCT scholars have made contributions to its work on urban material flows and on metals.

National research capacity in these fields remains thin. The "resource efficiency" concern has been formally branded into the work of the National Cleaner Production Centre hosted by the Council for Scientific and Industrial Research, but scholarly work has remained isolated to no more than a handful of studies, an important one in 2012 having been a DST-commissioned study on the higher-education dimension of modernised waste management.

Most importantly, outside the realm of natural resource management, very little scholarly work in South Africa appears to be tackling the difficult linkages between environmental sustainability and social development: conditions such as extreme inequality, poor basic education and extreme violence are likely to hinder green-economy efforts as much as they obstruct the struggle of our generation for a better quality of life for all. It is in this difficult crossover area that UCT researchers have located some of their research projects.

But is more research needed? Is it not enough to simply deploy tried and tested wind turbines and photo-voltaics so as to start greening South Africa's electricity supply?

A major critique emerging in the sustainability sciences is that traditional academic work entrenches the division of knowledge into discipline silos and thus hinders complete solutions to development challenges in the real world. Piecemeal solutions leave behind legacies for future generations. As a response, inter- and transdisciplinary approaches to knowledge generation are increasingly being considered an essential component of sustainability research.

UCT has started to recognise this imperative formally with the formation of the African Climate and Development Initiative. In the work of the Department of Chemical Engineering, this process has been more organic, and internal collaboration spans a diverse network of university-accredited research groupings, Signature Themes, and DST/NRF SARChI Research Chairs.

Research Project

Towards a Technology-specific Innovation System for Harnessing Waste-based Bioenergy

This project aims to unlock the energy and greenhouse-gas mitigation potential of waste biomass in South Africa, drawing on UCT's 20-year experience of researching clean technologies, waste minimisation and industrial ecology, and on supporting existing expertise of the University of Venda to realise key objectives.

The energy potential of waste biomass in Africa and South Africa has repeatedly been estimated to be sizeable. Theoretically, the project aims to better understand, and then help activate, the potential of a technology-specific innovation system to convert the identified potentials into sustainability gains, through processes of societal learning.

Much of the required technology exists in Asia and in Europe, but innovation is still required to make these technologies work in the South African context. Researchers at UCT are inspired by the recent spontaneous, bottom-up emergence of a technology-specific innovation system for biogas in Germany and are beginning to investigate the similar emergence of such an innovation system in South Africa.

The project is based at the University of Cape Town, in the Faculty of Engineering & the Built Environment, contributing to its "social innovation" ambitions, but tying into UCT's African Climate and Development Initiative. Since a key feature of biogas technology is its cross-cutting nature covering matters of sanitation, solid-waste management, energy supply and nutrient cycling, there are collaborations and interactions with colleagues in the Department of Civil Engineering, the Energy Research Centre and the African Centre for Cities. However, as the potential waste biomass is occurring in both urban and rural areas, as are South Africa's sustainable development challenges, the project is run in partnership with colleagues at the University of Venda who already have developed some expertise in biogas technology in rural settings.

Key features of the project work plan include describing the present state of the biogas innovation system and in so doing to identify mechanisms that induce or block adoption of the technology. The project also aims to stimulate the direction of the biogas innovation system by the planning, construction and operation of four demonstration facilities, designed to give effect to key functions of the university in a technology-specific innovation system. These demonstration facilities are harnessed in a targeted work plan to initiate learning of technologies and to track the uses to which this learning is put.

The project is funded by the National Research Foundation's Global Change, Society and Sustainability Research Programme, 2012–2014.

Technology Deployment for Sustainable Urban Development – "Township Caterers"

(In collaboration with UCT's student initiative "Engineers without Borders", 2010–2012, supported by the Vice-Chancellor's Strategic Fund)

'The number of people relying on the traditional use of biomass is projected to rise from 2.7 billion today to 2.8 billion by 2030. Using World Health Organization estimates, linked to our projections on biomass use, it is estimated that the household air pollution from the use of biomass in inefficient stoves would lead to over 1.5 million premature deaths per year, over 4000 per day in 2030, greater than estimates for premature deaths from malaria, tuberculosis or HIV/AIDS.' (World Energy Outlook, 2010).

Roadside catering is widespread in African towns and cities – and it mostly makes use of open fires. Fuel wood is either harvested or obtained from commercial or construction and demolition activities. With a significant amount of construction timber treated with insecticides, notably with chromated copper arsenate (CCA), it may well be that food preparation and consumption is undertaken in the presence of toxic heavy metals. This concern was investigated in several informal dwellings or townships in Cape Town and surrounding areas. The primary objectives of this project were:

- to determine whether or not CCA-treated wood was being used, particularly for food preparation, and what food it was being used to prepare;
- regardless of whether this concern could be confirmed, to do the investigation in such a way as to harness student social-engagement enthusiasm to impact on the well-established health burden of wood and smoke exposure.

If the result was found to be positive, the further objectives were:

- to determine the specific exposure to CCA from handling the wood, handling the ash, and breathing in the air from the combusted wood;
- to determine whether caterers exposed to CCA displayed elevated levels of these substances.

Since this was quite a diverse project, the consortium of involved parties was extensive. While it was driven by the Environmental and Process Systems Engineering Research Group, a strong partnership was formed with Engineers without Borders, with collaboration from UCT's Centre for Occupational and Environmental Health, the Centre for Transport Studies and the Environmental Policy Research Unit and, later, indispensable ties with the Energy Research Centre.

Professor Harro Von Blottnitz (back, right), who leads the "Township Caterers" project, together with students and caterers.

The following milestones have since been achieved: the collection and analysis of wood samples which confirmed some use of treated timber (CCA); the collection and testing from human subjects has also been undertaken. These findings are the subject of three journal papers to appear in 2013. They have been communicated to both the City of Cape Town's Air Quality Management Department and the South African Wood Preservation Association, with both bodies having initiated responses to address the problem. Lastly, Nyanga in Cape Town was selected as pilot site for testing the alternative technology (efficient wood stoves) that reduces exposure.

Environmental and Social Dimensions of
The Bio-economy

The past two decades have witnessed a surge of interest in the use of biodiversity, biological products, and biological processes in the mainstream economy, on a scale unprecedented in history, linking markets in virtually every corner of the globe.

Located at the interface of leading genetic and information technologies, and the juncture of a wide range of developing social, political and ethical concerns, the so-called bio-economy has fundamentally changed the way in which biodiversity is used and commercialised. New applications for genetic resources in the biotechnology industry have led to novel and varied demands for biodiversity, in forms previously unimagined. Intended products include new drugs, climate-resilient crops, industrial processing, novel ingredients for the food, herbal and personal-care industries, and other advances that generate significant benefits for society, financial returns for the companies that market products, and a range of benefits for countries that provide the biological material. At the same time, livelihood opportunities have opened up for rural communities engaged in commercially harvesting and producing supplies with high value in global and local markets.

The Chair's strong focus on engagement with communities, indigenous knowledge holders, and policy-makers, embeds within it a practice of engaged scholarship and social responsiveness.

There is a growing focus on the opportunities of the bio-economy throughout the industrialised and developing world. Yet, despite the profound societal implications of these developments, our understanding of the environmental and social dimensions remains poorly developed. This has been made all the more challenging by the immense changes in global economic systems, the rate of scientific change, and the information revolution. Environmental degradation and global climate change overlay these transformations and their multifaceted consequences on the bio-economy are only just beginning to be recognised.

In 2012, UCT was awarded a DST/NRF South African Research Chair in the Environmental and Social Dimensions of the Bio-economy. The Chair is located in the Department of Environmental and Geographical Science, and provides an exciting opportunity to advance knowledge in this newly emerging arena by catalysing the advancement of research and understanding across and within disciplines, building a critical mass of intellectual capacity, enabling human capital development and in particular a new cohort of skilled postgraduate students, and informing policy and public debate in this rapidly evolving but underdeveloped field. Its strong focus on engagement with communities, indigenous knowledge holders, and policy-makers, embeds within it a practice of engaged scholarship and social responsiveness, with the objective of developing a pioneering, highly collaborative and globally relevant knowledge hub with international stature.

South Africa's mix of developed and developing economies, well-developed scientific and industrial infrastructure, unique biodiversity and rich indigenous knowledge systems provides an exceptional foundation for the research, which focuses on four central themes.

The first theme centres on access and benefit sharing, bio-discovery and the bio-economy, aiming to strengthen the conceptual underpinnings of access and benefit-sharing through enhanced understanding of implications for commercial sectors involved in the global and national bio-economy, and their responses to environmental and equity considerations. The research incorporates global reviews of the key sectors (e.g. pharmaceuticals, herbal medicine, nutraceuticals, industrial biotechnology, agriculture, personal care and cosmetics, food and beverage) involved in the commercial use of biodiversity, providing analyses of the scientific and technological developments that underpin bio-discovery, and the market, industry and societal trends that drive demand for access to genetic resources and shape benefit-sharing, economic development and environmental sustainability.

The second theme links closely to the first, but with a stronger focus on the broader use of biodiversity by rural communities, and links to livelihoods and poverty alleviation. The objective of this component of the research is to deepen knowledge and understanding of approaches to biodiversity use and trade that alleviate poverty, reduce inequality and improve environmental sustainability. Building on existing research, this objective also has a strong creative component, revealing the stories of indigenous plants, the communities that use them, and the paths they travel as indigenous knowledge, identities and resources are transformed into drugs, cosmetics, food and flowers for the global consumer market. This integrates a variety of disciplines in a holistic way – anthropology, environmental science, botany, photography and the assemblage of an important archive.

The third theme focuses on the elucidation of governance approaches in Southern Africa that strengthen the rights of custodians of biodiversity and traditional knowledge holders, facilitate implementation of the Convention on Biological Diversity and the Nagoya Protocol, and stimulate environmentally sustainable and socially just approaches in the bio-economy. A second stream of research within this objective investigates the so-called innovation chasm between research results, commercialisation and socio-economic outcomes, well recognised as a constraint towards achieving significant outcomes of the bio-economy.

The research agenda of the Chair is strongly interdisciplinary by nature, aiming to build UCT-wide collaborations in addition to those at national and international levels.

The fourth theme is an evolving one: to deepen understanding of the environmental and social impacts of emerging technologies within the bio-economy such as genetic engineering, industrial biotechnology and biofuel production.

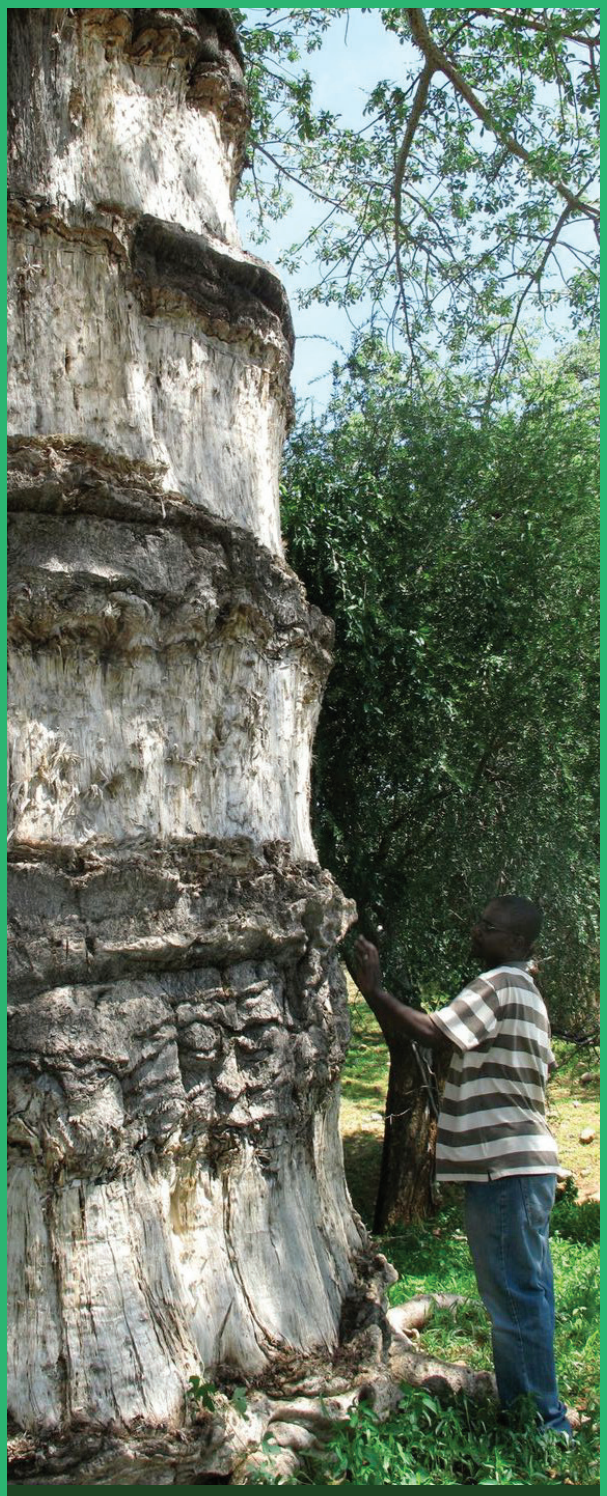
The research agenda of the Chair, which has been filled by Associate Professor Rachel Wynberg of the Environmental Evaluation Unit (also see page 43) is strongly interdisciplinary by nature, aiming to build UCT-wide collaborations in addition to those at national and international levels.

Indeed, UCT is ideally placed to host the Chair since a wide range of departments are engaged in aspects of the bio-economy, located in almost every faculty across campus. Activities include scientific research and development to generate particular applications; ecological studies to assess sustainable use; legal scholarship to investigate intellectual property rights, traditional knowledge and biosafety regimes; social science analysis to address the myriad of questions raised by this field of enquiry; and initiatives in the fine arts, reflecting the increasing confluence of arts and sciences to find innovative solutions to societal problems. Obvious synergies exist with existing Research Chairs in Drug Discovery (Chemistry), Bioprocessing (Chemical Engineering), Customary Law, and Intellectual Property Rights and Biotechnology (Private Law), as well as the African Climate and Development Initiative. It is intended that activities between these spheres will have a synergistic effect, catalysing new areas of research inquiry and stimulating transdisciplinary analyses that are often difficult to undertake discretely.

DST/NRF SARChI Chair
associated with this theme

Environmental and Social Dimensions of the Bio-economy

Profiled on page 43



Research Groupings
associated with this theme

Environmental Economics Policy Research Unit

The Environmental Economics Policy Research Unit (EPRU) is the South African branch of the Environment for Development initiative. This is a capacity-building programme in environmental economics, which focuses on research, policy advice, and teaching in China, Central America, Ethiopia, Kenya, South Africa, and Tanzania. EPRU is a collaborative association of researchers specialising in environmental and natural resource issues.

The unit was established in 2007 to promote sustainable development and poverty reduction in Southern Africa. To achieve this, EPRU aims to enhance the effectiveness of environmental policy-making by adopting a threefold strategy of research, teaching and policy consultation.

Research has been concerned with farm workers' wages, land use and rural poverty, and inequality among subsistence fishermen.

During the last five years, EPRU's policy-relevant experience in research pertaining to ecosystems management, biodiversity conservation, air quality and water quality has grown extensively. The centre also has previous research capacity and experience relevant to the socio-economics of agriculture, fisheries and conservation. Specifically, this strain of research has been concerned with farm workers' wages, land use and rural poverty, and inequality among subsistence fishermen, as well as the role of community-based wildlife conservation in poverty mitigation. EPRU has successfully worked with a number of local and national stakeholders on medium-sized projects, such as the South African National Parks (wildlife sector), the Department of Water Affairs and Forestry (water sector), the Department of Environmental Affairs and Tourism (marine and coastal management), and the City of Cape Town (air-quality management and energy savings). In the next few years, EPRU plans to bid for larger research projects that will enhance collaboration among EPRU research fellows, with other researchers and, importantly, with key stakeholders.

Director: Associate Professor A Leiman
E-mail: tony.leiman@uct.ac.za
Web: http://www.efdinitiative.org/south-africa

Energy Research Centre

The Energy Research Centre (ERC) conducts high-quality, targeted and relevant research, as well as offering postgraduate opportunities at master's and doctoral levels. The main research areas are energy efficiency; energy, environment and climate change; energy poverty and development; and energy systems analysis and planning. The staff of the ERC have qualifications in engineering, natural and environmental sciences, urban and regional planning, economics, law, politics, sociology, and anthropology.

Director: Professor KF Bennett
E-mail: kevin.bennett@uct.ac.za
Web: http://www.erc.uct.ac.za

Centre for Occupational and Environmental Health Research

The Centre for Occupational and Environmental Health Research aims to be a principal centre of occupational and environmental health research, teaching and training, occupational medical clinical services, policy advice, technical consultancy services and advocacy, and a source of supportive outreach activities in South Africa, parts of Africa, and internationally. It conducts multidisciplinary research, teaching and service provision that integrate laboratory, clinical, epidemiological, and policy skills in relation to occupational health problems that have high priority in Southern Africa. This is in order to facilitate identification and improved characterisation of these and other problems, and to better understand the determinants of these problems and their solutions.

The centre explores and develops means of maintaining the health of individuals and the environment, especially the work environment, and of preventing the development of health problems in those exposed to injurious environments at work or more generally. Public policy research is conducted into issues ranging from toxic or injurious exposures through to health surveillance, and the functioning of relevant health services. Inter-institutional research, teaching and service (including outreach) collaboration and capacity development are priorities of the centre, along with fostering local and global networks for occupational and environmental health promotion through collaboration with the United Nations and other agencies, notably the World Health Organisation (WHO). The centre is currently a WHO Collaborating Centre for Occupational Health.

Director: Professor A Dalvie
E-mail: aqiel.dalvie@uct.ac.za
Web: http://www.coehr.uct.ac.za

Environment Evaluation Unit

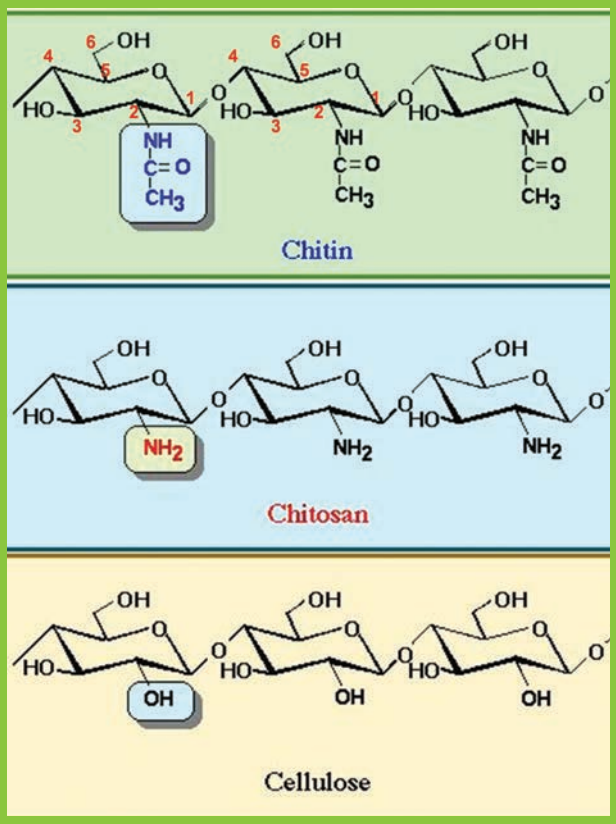
Please refer to page 110

The Chemical 'Chameleon', Versatile Chitosan makes for an Array of Potential Applications

Dr Anwar Jardine's research group in UCT's Department of Chemistry has been investigating chitosan, derived from chitin, a natural polysaccharide that is the second most abundant organic source on earth. Chitin is partly responsible for the robust hard shell or exoskeleton of insects and crustaceans, with a structure that is similar to cellulose.

Chitin and chitosan have an array of potential applications, and numerous products have already reached the market for the treatment of a variety of diseases, including arthritis, inflammatory bowel disease, and general inflammatory damage.

The growth of the chitin and the chitosan market worldwide is propelled by the new manufacturing technologies and expansion in the application domain – these new, high-end products are worth considerably more than the low-cost polymers that previously dominated the industry, spurring on innovation.



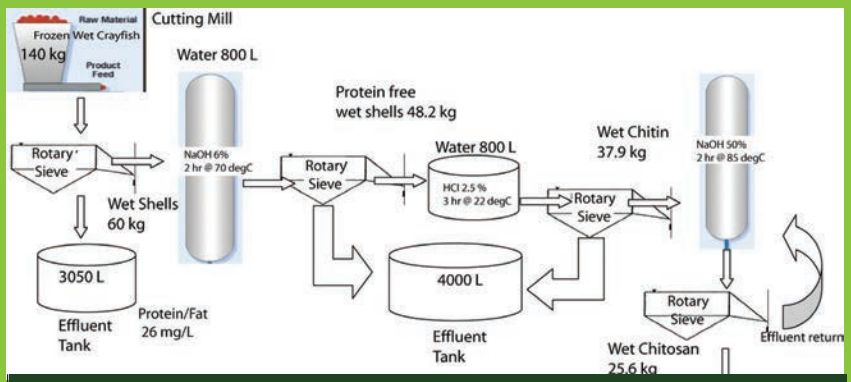
Dr Jardine and his team have modified chitosan by converting the 6-hydroxy group in the polymer to a 6-amino group, turning a sparingly soluble polymer into one that is now completely soluble in aqueous media. This forms the basis of a patent that has recently been granted in the USA, with other patent applications pending. Solubility in aqueous solutions has broadened the scope of application, particularly in "green" technologies that seek to replace or minimise the use of organic solvents in chemical processes.

The main source of the raw material is the shell of the Southern Spiny Lobster, *Palinarus gilchristi*, after removal of the tail for sale. It is estimated that in South Africa about 440 tons of this waste are available. This shell exoskeleton can be transformed into a backbone of another sort – a soluble, modified chitosan "backbone" molecule that can be used as a chemical catalyst support. The team added a platinum group metal catalyst to this novel chemical backbone, enabling efficient, heterogeneously catalysed synthesis of fine chemicals in "green" solvent systems, the subject of a further patent.

Currently, waste shells are either discarded while at sea, or landed and sold locally as flavouring agents at between R5 and R10 per kilogram. Although the yield of high-quality chitosan is only 3 to 5% based on wet-shell weight, the potential market value of up to R3000/kg chitosan is attractive and higher-value-added derivatives are even more enticing.

The modified backbone is currently being explored in a water purification application for the reduction of high

Dr Anwar Jardine (centre) and the chitosan research group in the Department of Chemistry.



Local chitosan manufacturing pilot process

Milled crayfish shells (above right) and chitosan (above)

salt load. A British Council Africa Knowledge Transfer Partnership sponsored project is seeking to improve the poor groundwater quality on the arid West Coast, at Garies in the Kamiesberg municipality (Northern Province). If successful, this will have a significant impact on the local community, whose development is severely hampered by the scarcity of local potable water, with water needing to be trucked in at certain times. The first 'laboratory phase' of the project is complete and the pilot in Garies will strive to translate the laboratory process into the field, ultimately improving the municipality's "green" and "blue drop" water quality and management rating.

Another successful application has seen the use of this modified chitosan as a solid support for the chromatographic separation of fish oil. The fish oil is a by-product of the pelagic fishing and has a low commercial value owing to competing vegetable oils. This silver-based "argentation chromatography" allows saturated fatty acids to be separated from unsaturated fatty acids. Unsaturated fatty acids have great nutritional value (e.g. omega-3 and -6 fatty acids). Saturated fatty acids, on the other hand, have cosmetic value or serve better as feedstock for biodiesel.