

KSA 3: WATER USE & WASTE MANAGEMENT



SCOPE

The **Water Use and Waste Management** KSA focuses mainly on the domestic, industrial and mining water sectors. It aims to proactively and effectively lead and support the advancement of technology, science, management and policies relevant to water supply, waste and effluent management, for these sectors. This KSA also supports studies on institutional and management issues, with special emphasis on the efficient functioning of water service institutions and their viability. Research on infrastructure for both water supply and sanitation is included. A further focus is on water supply and treatment technology serving the domestic (urban, rural, large and small systems) as well as the industrial/commercial and mining sectors of our economy. This KSA also focuses on waste and effluent as well as reuse technologies that can support the municipal, mining and industrial sectors and improve management in these sectors with the aim of improving productivity and supporting economic growth while minimising the negative effect on human and environmental health.

The provision and supply of water of adequate quality and quantity for economic and public health purposes remain continuous challenges. Water is a finite resource and, specifically in the context of South Africa, is becoming incrementally scarce. Managing water use

and the waste released to the water environment is thus of paramount importance to ensure the sustainability of the resource and the activities relying on it. Water use and waste management in South Africa is consequently a key factor for social and economic growth, as well as for our environment. The entire way we think about and use water is thus an important factor in determining our future. In recent years the focus of the KSA has been on supporting the implementation of various pieces of legislation that impact on the provision of sustainable water services. The support was in the form of unpacking and understanding key elements within legislation and the impact on the water services sector. The result has been a bias towards developing guidelines and tools to assist new and emerging municipalities and politicians to understand their responsibilities, which also included repackaging information of a technical nature. In the process we have maintained a balance with dealing with cutting-edge technological advances and have been concentrating on their application and commercialisation. Developing innovative processes and technologies for water purification, reuse and treatment of wastewater from domestic to industrial and mining activities has been and is of even greater importance to our country, especially in the light of problems related to the deteriorating quality



of our water resources and the rising costs and reliability of energy. Considering the emerging challenges, research in the KSA will continue to focus on greater innovation and development of cutting-edge technologies to respond

to the issues of poor O&M, competency and capacity constraints, reuse, energy efficiency, climate change constraints, emerging contaminants and the aspect of drinking water quality.

OBJECTIVES

The strategic objectives of KSA 3 are as follows:

- To support the efficient functioning of water service institutions and their viability in order to sustain water services in rural and urban areas
- To develop innovative technologies, processes and procedures that address aspects related to bulk water supply, water treatment technology, distribution and water quality
- To develop technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector
- To quantify water use and waste production, predict impacts (risks) over the short-, medium- and long-term, and develop and apply methods of prevention, minimisation, reuse, recycle, recovery and beneficiation with the aim to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries
- To provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector

THRUSTS AND PROGRAMMES

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: The efficient functioning of water service institutions and their viability are key to sustaining water services in rural and urban areas. The focus of this thrust is to address strategic research aspects related to policy issues, institutional reform, regulation, infrastructure

management, water-related competencies and capacity required for the strengthening of water institutions (water services providers, water services authorities, water boards, national departments) in providing sustainable water services.

<p>Programme 1: Cost-recovery in water services</p>	<p>Scope: The issue of cost-recovery has been identified as a critical aspect affecting sustainable services. In an environment where genuine poverty affects cost-recovery, this programme intends to develop innovative strategies and processes to tackle the problem. The focus will be on generating in-depth knowledge of the problem and testing new approaches.</p>
<p>Programme 2: Institutional and management issues – Water services</p>	<p>Scope: Relationships and partnerships between service providers, both external and internal, are important prerequisites to sustainable water service delivery. This programme’s objective is to generate knowledge and processes that would support this new form of service delivery. Innovative management techniques are a necessity for viable and sustainable water service provision. This programme intends to find innovative solutions to critical problems with the financing and management of essential services such as water supply and sanitation.</p>
<p>Programme 3: Innovative management arrangements – Rural water supply</p>	<p>Scope: The focus of research within this programme is to provide support to water service institutions with special reference to sustainable cost-recovery and implementation of the free basic water policy; key performance indicators for monitoring and evaluation of service delivery; guidelines for sound management of water service institutions and development of effective strategies for promoting an integrated approach to rural development.</p>
<p>Programme 4: Regulation of water services</p>	<p>Scope: Regulation of water services is important for the sector to achieve improved functioning and performance in the delivery of water and sanitation services, to the benefit of the population. Furthermore, it ensures greater efficiency and improved management of infrastructure and customers. This programme will support, through knowledge creation, the development of an effective water regulatory environment.</p>
<p>Programme 5: Water services education and awareness</p>	<p>Scope: A fully-informed community or individual plays a vital role in the sustainable use of water services, which contributes to water efficiency and improved environmental health. This programme will address education and awareness aspects which contribute to efficient water use, improved hygiene behaviour and sustainable services.</p>



THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: The provision and supply of affordable and reliable water of acceptable quality and quantity for drinking (domestic) and economic (industrial/commercial and mining) activities, remain continuous challenges. Research support for these activities is the focus of

this thrust. The objective of this thrust is to develop innovative technologies and processes that address aspects related to bulk water supply, water treatment technology, distribution and water quality.

<p>Programme 1: Drinking water treatment technology</p>	<p>Scope: The programme aims to acquire adequate understanding of potable water treatment processes and related activities and to be able to assist in treating our scarce water resources in the most efficient and cost-effective way to an acceptable quality for potable and industrial use. Expected outcomes include improved and more cost-efficient process technologies, increased operational efficiency of treatment plants and an improved manpower training level and knowledge base.</p>
<p>Programme 2: Water treatment for rural communities</p>	<p>Scope: This programme aims to produce innovative and appropriate water treatment and supply technologies and processes that will ensure an adequate supply of safe and clean drinking water for rural communities.</p>
<p>Programme 3: Drinking water quality</p>	<p>Scope: The programme aims to protect human health by ensuring that water supplies are of acceptable quality and standards. Outcomes include improved analytical methodologies, treatment technologies and hygiene practices.</p>
<p>Programme 4: Water distribution and distribution systems</p>	<p>Scope: The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated potable water to end-users. The programme has the following expected outcomes: to develop reliable processes in predicting and improving the operational efficiencies in distribution systems, with the purpose of reducing both capital and operational costs; to ensure that the quality and quantity of water is maintained in the distribution system – from the water treatment plant to the furthest end-user; and to develop innovative methods, tools and processes that will improve system integrity and reliability.</p>

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Scope: This thrust focuses on the development of technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector. This includes the reticulation, treatment and management of the residues. The challenge is to implement fitting solutions for a particular application that will remain functional throughout the intended lifespan of the installed infrastructure. This

includes the responsible management of the wastewater sludge and faecal sludge that is generated. The need for innovative technologies and solutions is recognised as we prepare for the future – achieving more stringent effluent discharge standards, developing acceptable non-waterborne sewerage solutions, reliable treatment of ever-increasing high-strength domestic wastewater, informing future policy, etc.

Programme 1: Emerging treatment technologies – Preparing for the future

Scope: It is imperative to develop technologies which can achieve future policy objectives and stricter standards. It is also recognised that research generates information which could inform future policy. This programme encourages the development of technologies to address the future anticipated municipal waterborne sewage and sanitation needs as well as to support Government by informing future policy. It supports development of technological solutions addressing, amongst others: reuse, recovery, non-waterborne sewerage solutions, grey-water management, peri-urban sanitation solutions, high-strength effluent treatment, industrial and domestic effluent co-treatment, etc. It also supports research aimed at informing future policy through data interpretation, projections, risk assessments, addressing emerging pollutants, predictive models, etc.

Programme 2: Application of appropriate technologies and tools

Scope: This programme addresses the improvement and innovative application of existing 'fit for purpose' technology for waterborne sewage treatment and on-site sanitation. The objective is to optimise appropriate application to consistently achieve strict standards, with added benefits such as cost saving, ensuring ease of operation and maintenance, and improving reliability and energy efficiency. The integration of social and local economic development objectives is encouraged. The programme further focuses on the technical sustainability of wastewater treatment and sanitation services by critically appraising existing policy (including effluent discharge standards) and impacts.



Programme 3:

Stormwater and sewerage systems

Scope:The programme supports the strategic and technical aspects of managing stormwater and sewerage and their impacts in urban, peri-urban and rural contexts. The development of generic stormwater and sewerage planning and technology selection, design and maintenance tools is encouraged to address current needs. In order to address anticipated needs, the programme supports research focusing on improved technology including water-sensitive urban design (WSUD) and stormwater reuse. It will cover technical design, operational, maintenance, refurbishment and management aspects of stormwater and sewerage reticulation systems, to provide sustainable infrastructure in the extended delivery of sanitation services as a national priority.

Programme 4:

Wastewater sludge and faecal sludge management

Scope: All wastewater treatment and on-site sanitation facilities generate a solid/sludge that needs to be managed responsibly. This programme focuses on research dedicated to improve wastewater sludge and faecal sludge management practices. Research on characterisation, emerging technologies and solutions, anaerobic processes for stabilisation, minimisation, de-watering, disinfection and beneficiation is encouraged.

Programme 5:

Sanitation technology and innovations

Scope: To develop innovative tools and technology which support appropriate sanitation that is socially, environmentally and financially sustainable.

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Scope: Water is a strategic issue to the industrial sector. While water usage by the industrial sectors is not as great as, e.g., agriculture or domestic consumption, the impacts of the pollutants in industrial wastes and effluents on health and the environment can be significant, costly and long-lasting. The aim of this thrust is to quantify water use and waste production, predict impacts (risks) over the short-, medium- and long-term, and develop and apply methods of prevention, minimisation, reuse,

recycle, recovery and beneficiation. This thrust also aims to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries. In addition, Thrust 4 establishes the governance, policy and regulatory environment that currently exists and the enabling environment that will be required to change behaviours to conserve water, grow the economy, protect society and the environment.

Programme 1: Emerging challenges and solutions for the 21st century

Scope: This programme seeks to look at major challenges that may face South Africa in future at a water quality, quantity, and security level. It will explore emerging fields in science and engineering, such as nanotechnology, to provide solutions to these challenges. In addition to seeking new solutions, this programme will also investigate new and emerging industries, their water needs and the associated threats to health and environment. The concept of sustainable future industrial complexes and their water management will allow for better planning and regulation of new industries, enabling improved adoption of integrated resource management systems, processes and tools.

Programme 2: Integrated management

Scope: This programme focuses on integrated and innovative management arrangements, e.g., public-private partnerships (PPP), to support industry and government programmes which may be site-, catchment- and/or region-specific. While the programme will focus on water, it aims to promote a more holistic approach to resource (water, energy and carbon) management by industries to bring about sustainable approaches to water and wastewater management ensuring that liabilities (waste) are turned into assets (resources) for the benefit of the environment, society and economy.



Programme 3:
Quantification,
prediction and
minimisation of
water use and waste
production

Scope: In order to prioritise those facets of industrial water management that need the most urgent attention, it is important to quantify the water used and waste produced by different sectors. This programme will also look to develop new methodologies and models to aid in quantification, prediction and evaluation of data. The environmental consequences of waste products are almost always long-term in nature and these long-lasting (legacy) effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of. Thus, this programme also aims to establish and improve pollution prediction capabilities appropriate to South African conditions and to develop cost-effective techniques and approaches to minimise or reduce the impact that legacy and new waste products have on the environment.

Programme 4:
Governance,
policy, regulatory,
and economical
instruments to
improve industrial
water management

Scope: The regulatory authorities are responsible for authorising and regulating the impact of industrial waste on the quality and quantity of our water resources. Traditionally the resource-intensive command-and-control approach was used almost exclusively to manage water quality. Internationally, use is increasingly made of indirect economic or other instruments to supplement or even replace the command-and-control approach to water quality management. These new approaches are believed to be more cost-effective and to improve equity. Both the established and new approaches are being investigated and refined in order to support improvements to the governance, policy, regulatory, self-regulatory, and financial mechanisms that could be used to control and reduce the negative environmental effects associated with industrial waste. This programme will largely look at these mechanisms from an industry perspective in order to improve, review and enable implementation.

Programme 5:
Water efficiency,
cleaner production,
beneficiation
and treatment of
industrial effluents

Scope: This programme looks at water use efficiency and associated tools, methodologies and systems as a primary driver of reduced effluent generation. In spite of efforts to minimise waste production it is acknowledged that effluent production will for the foreseeable future remain an expected consequence of industrial activities, and thus this programme aims to support the development of a range of processes and techniques for effective beneficiation, recovery, reuse, recycle, disposal and ultimately treatment of industrial effluents. The international trend towards waste management is to minimise the production of waste by adopting cleaner production processes and green chemistry concepts for chemicals. Approaches such as life-cycle analysis are employed to ensure that the net effect is positive and does not merely represent the transfer of negative effects from one sector or environmental medium to another. In addition, the programme entails the exploration and exploitation of in-process recycling and reuse opportunities prior to end-of-pipe treatment solutions. Expected outcomes include the potential recovery of materials, water and energy for beneficial reuse, and fundamental scientific/engineering support for process development, and thus longer-term initiation of the secondary economy opportunities within South Africa.

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Scope: The usage of water in mining and mineral processing/refining produces high volumes of solid wastes and liquid effluents. Some mining activities generate acid mine drainage (AMD) or other mining-impacted waters. This thrust aims to provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector. Future

operations will almost exclusively take place in water-scarce regions (e.g. Waterberg, Eastern Limb) and their development will require reallocation of already stretched resources through, e.g., improved water demand and water conservation management. Additional priorities will include brine handling, biological sulphur compound transformation and aversion of future impacts.

Programme 1: Water use and waste production

Scope: This programme focuses on investigations into quantification of water used and waste produced by the sector, currently, and predicting and quantifying the short-, medium- and especially long-term impacts the wastes generated will have. The environmental consequences of mining activity are almost always long-term in nature, with impacts that last for centuries. These long-lasting effects were often not fully understood in the past, and consequently not properly considered. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impacts of their past and present operations and to indicate how these will be remedied, as well as how such consequences can be avoided when planning future operations.

Programme 2: Regulatory, management and institutional arrangements

Scope: The creation of sustainable arrangements (e.g. public-private partnerships) that enable the mitigation and prevention of the environmental, social and economic legacies of the mining and minerals industries is complex. Priorities include addressing the treatment and supply of bulk water using acid mine drainage (AMD), a realistic estimate of non-point-source pollution relating to the waste discharge charge system and determining the price elasticity for water use of the sector (determine the potential to decrease water use through tariff increases). This programme interrogates such aspects from the perspective of the mining sector. (Note: Policy development falls under KSA1).



<p>Programme 3: Minimising waste production</p>	<p>Scope: This programme focuses on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life-cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. Identification of opportunities to convert liabilities into assets and holistic, long-term research into the beneficial use and recovery of brines, their solutes, and other waste products, are also included.</p>
<p>Programme 4: Mining in the 21st century</p>	<p>Scope: The emerging challenges related to avoiding recreating the legacies of past operations call for emerging solutions. Programme 4 will investigate the prediction and avoidance of long-term water impacts and implications associated with establishing new operations within different geographical areas. It will also actively pursue beneficiation initiatives, re-mining of wastes, etc. (especially innovative ideas and piloting/scale-up).</p>
<p>Programme 5: Low-volume mined products</p>	<p>Scope: Much research attention has been paid to coal and gold mining; however, other quarried or mined products such as radio-nuclides and platinum group metals also require consideration and in some cases present unique challenges. Water use and demand management, water-conserving metallurgical and extraction processes and investigation of the impacts and amelioration of mine discards specific to these products will be addressed in this programme.</p>

THRUST 6: WATERSMART FUND

Scope: Drinking water and commercial activities have a high cost and assurance attached to them, as well as growing competitive demands. The wise and efficient use of this water has a profound impact on our water environment, resources and investments. Thus, this fund

will support research, demonstration and development of any innovative idea, technology or process which supports the efficient use, reuse and conservation of our precious water and related energy efficiency in the domestic, industrial and mining sectors.

RESEARCH PORTFOLIO FOR 2016/17

COMPLETED PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2:

Institutional and management issues – Water services

Assisting municipalities to determine the most appropriate indicator for funding allocations toward operations and maintenance

PDG

1121

The poor state of operations and maintenance of infrastructure in South Africa, not only in water services but across all sectors, is widely bemoaned. One of the overall findings of the CIDB and CSIR report was that few municipalities put enough of their budgets aside for infrastructure maintenance. Within this context, assisting municipalities to determine what level of funding they should allocate to maintenance is of vital importance and it is for this reason that the WRC commissioned this study. The exploratory methodology was based largely on a review of the literature, interviews with municipalities and other stakeholders, and some desktop analysis. Within this scope one can only draw tentative conclusions and make suggestions as to where further work is necessary.

Key conclusions emanating from the study are as follows:

- There remains significant confusion about definitions and terminology in the maintenance space, and more work needs to be done to ensure consistent and clear definitions. The alignment between CIDMS and mSCOA has been a good start here.
- Further clarity on what expenditure items should be considered as 'maintenance' is needed in order to ensure that reported expenditures on maintenance are referring to the same thing. mSCOA alone is unlikely to address this as municipalities will need guidance on which entries under the 'Item' segment should be recorded as maintenance under the 'Project' segment.
- The MFMA Circular 71 benchmark of 8% of the carrying value of PPE and investment property is a significant improvement on benchmarks based on the percentage of the municipal budget but it does not have a theoretically sound basis. It may be adequate as an indicator for high level monitoring by National Treasury but should not be used by municipalities themselves in determining whether they are making adequate allocations to maintenance. In interpreting



performance against this benchmark, National Treasury should bear in mind that it overstates maintenance needs in water and sanitation systems that are new but understates it in systems that are older. It will also be more or less accurate depending on the composition of the water and sanitation assets.

- Ultimately, the only way to assist municipalities to make adequate financial allocations to maintenance is to support them in progressively implementing sound infrastructure asset management and life cycle costing.

Cost: R237 318

Term: 2016 – 2017

Adaptive climate change technologies and approaches for local governments: water sector response

Hydrosoft cc; Development Bank of Southern Africa; Department of Environmental Affairs; SALGA; Department of Cooperative Governance and Traditional Affairs; University of Cape Town; CSIR; University of Pretoria; Hydrosoft Institute; Department of Water and Sanitation

2283

Local government institutions, especially municipalities, are currently looking at how they can address the impacts of climate change as part of their business process. However, there is very limited guidance regarding how this can be achieved and, even less so, guidance that is directly linked to their business, location, existing

infrastructure, resources and other unique factors. In this study, a water sector climate change adaptation guide was developed. The guide deals with the selection of relevant water sector adaptation technologies and approaches for specific climate change impacts over the short, medium and long term. Specific objectives for this study include the following:

- To investigate if all or just some municipalities will need to adapt to climate change
- To develop a set of criteria to classify adaptation technologies and approaches
- To identify appropriate adaptation technologies and/or approaches to climate change at local government, community and/or household level
- To map the adaptation technologies for near-, medium- and long-term planning while taking into account the types of municipalities – rural, urban and metro
- To ascertain the institutional and capacity requirements of local government to roll out a climate change adaptation strategy
- To define practical implementation steps and planning horizons that will be required
- To provide a review and way forward for current research that could provide future solutions and address the gaps in the sector to meet climate change needs

Cost: R1 500 000

Term: 2013–2016

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1:

Drinking water treatment technology

Establishing the current practice and prospective management strategies for water treatment residues handling, disposal and reuse in South Africa

Umgeni Water; University of KwaZulu-Natal (Westville);
Rand Water

2361

About 53% of waterworks in the sample set were not complying with legislation and some of these waterworks were operated by water utilities that have the capacity and resources to investigate alternative methods of water treatment residue (WTR) reuse and disposal. This suggests that current legislation for WTR management is too stringent and those that are complying are doing so at a much higher cost. Dialogue and co-operation through focused meetings and workshops between the water sector and the Department of Environmental Affairs (DEA) and other relevant government departments should be intensified to ensure stakeholder buy-in to an environmentally and financially sustainable solution to WTR management. A concerted effort should be made by water practitioners to engage with the DEA and provide the necessary technical input to assist the legislators and regulators with the creation of appropriate legislation for WTR management, especially with regard to challenges due to the blanket classification of WTR with other hazardous wastes. The fact that most of the

contaminants found in the WTR emanate from the raw water indicates that the blanket classification of WTR as hazardous should be re-evaluated and input should be gathered from both regulators and water practitioners. This will reduce the cost of analysis and ensure adherence to relevant regulations, including measurable environmental compliance.

Cost: R1 000 000

Term: 2014 – 2016

Degradation of emerging micropollutants by combined advanced oxidation with immobilized plasmon titanium dioxide nanocomposites in an electrohydraulic discharge reactor

University of the Western Cape; University of Fort Hare

2364

Emerging micropollutants such as bisphenol-A and 2-nitrophenol present a great threat in drinking and wastewater due to their adverse effects. These contaminants are also poorly understood, not easily biodegradable, unregulated and have become a huge public health issue as they have been detected in different water sources at nanogram per litre to microgram per litre concentrations. The aim of this study was to investigate the application of combined synthesized Ag-immobilized or plasmon-enhanced TiO₂ composites and dielectric barrier discharge (DBD) reactor for the degradation of



these micropollutants. The results obtained indicated that the removal efficiency of BPA and 2-NP by the DBD alone at 80 minutes of reaction time was 67.22% and 56.8%, respectively. The combined DBD with 2.4% Ag-doped TiO₂ nanocomposites achieved 89% and 81% removal efficiency for BPA and 2-NP, respectively, as compared to 67.22% and 56.8% obtained while using the DBD system alone. This shows that the incorporation of supported Ag-doped TiO₂ photocatalysts improved BPA or 2-NP removal efficiency by 21.8% and 24.2%, respectively, compared to DBD alone. The supported Ag-loaded carbon-doped catalyst can be recycled due to maintenance of its crystalline nature and pure anatase polymorph after four repeated applications. The results obtained for the change of TOC were rather low due to formation of the intermediates that were quite refractory to further mineralization. The major shortcoming of the supported Ag-doped TiO₂ photocatalyst was the leaching of metallic species such as Fe, Cr and Ni from the stainless-steel mesh support.

Cost: R787 400
Term: 2014 – 2017

Evaluation and selection of an appropriate automatic coagulant dose control system for conventional water treatment plants

Umgeni Water; University of KwaZulu-Natal (Howard College); Rand Water

2396

When used in the right environment, the SCD technique is the most appropriate automatic dose control

system that is currently available in South Africa. The mathematical model based on historical water treatment plant data may be applied for an automatic coagulant provided great care is taken in the quality control of analytical measurements that constitute the historical datasets. The mathematical model, once established, may be applicable to water treatment plant optimisation in addition to automatic coagulant dose control.

Cost: R450 000
Term: 2014 – 2016

Programme 2:

Water treatment for rural communities

Application of high-throughput green liver systems for sustainable water purification using endemic aquatic macrophytes

Nelson Mandela Metropolitan University; Technical University of Berlin

2367

Overloading of wastewater treatment systems, along with the inadequate provision of sewerage in many rural areas, can result in release from water treatment facilities of very poor quality surface waters that contain high concentrations of emerging organic contaminants. These xenobiotics include pharmaceuticals, and frequently also cyanotoxins where polishing ponds precede release. The released water typically also contains high levels of nutrients. The reliance on raw water for household use, although diminishing, is still high, and the use

of raw water that may contain xenobiotics or natural toxins, for agriculture, aquaculture and recreation, also poses certain risks. In addition to these problems, the increased costs required for potable water production from contaminated raw waters is significant, and often beyond the capabilities of smaller water purification plants. The added ecotoxicological concerns and the emergence of antibiotic resistance in environmental samples, with the implications for emerging resistance in pathogens, indicates an urgent need to address these contaminants. A low-technology, low-maintenance and low-cost solution is therefore required for treatment of such contaminated raw waters, either at source or prior to abstraction. The system should also be suitable for purification of an impoundment in situ. The report proposes a biological system based on the 'green liver' systems successfully implemented in China and Brazil. This system, which follows the same principles as the ecological infrastructure, was developed and tested in the laboratory, using selected macrophytes. A series of tests and combinations of plant species and the targeted contaminants, including nevirapene, ampicillin and others, were used in the experiment. The testing chambers also allowed different concentrations and flow rates to be tested. Plants were tested for biotransformation, bioaccumulation and depuration. Ultimately, the best sequence of macrophytes in removing specific contaminants was established in a model called the High Throughput Sequential Phytoremediation System (HTSPS). This innovative model has proven effective in purifying emerging contaminants at laboratory scale; it is now ready to be piloted in the field.

Cost: R450 000
Term: 2014 – 2017

Design, construction and monitoring of a sustainable domestic rainwater harvesting multi-tank treatment station at a central location in Enkanini informal settlement, Stellenbosch

Stellenbosch University; Sustainability Institute
2368

In order to provide clean and safe drinking water to communities collecting rainwater, the development of effective water treatment methods is required. Pasteurization has been recommended as a possible treatment method, i.e., the closed-coupled solar pasteurization treatment system utilised in WRC Project K5/2124/3. However, it is well known that pasteurization may not improve the chemical quality of harvested rainwater and for this reason the roofing materials utilised as the catchment areas for rainwater harvesting systems need to have no primary influence on the rainwater quality. Social perceptions of implementing a pilot domestic rainwater harvesting (DRWH) multi-tank station in the Enkanini informal settlement as an alternative water supply were investigated. Approximately 61% of the respondents were familiar with the concept of rainwater harvesting and while 32% were unfamiliar with the concept, 67% of the respondents indicated that they would utilise harvested rainwater for their daily water needs. Among the respondents, 77% indicated that they would utilise the rainwater for cleaning the house and bathing, 65% would utilise the rainwater for cooking,



while 46% will use it for potable or drinking purposes. Additionally, 67% perceived rainwater to be clean and safe to drink. This revealed a general lack of awareness of the potential health risks of consuming untreated rainwater. Moreover, most of the respondents (68) confirmed that they would use the rainwater instead of municipal water should the tanks be close to their homes. The effect of environmental factors on locally produced and utilised shack dwelling building materials and on the chemical and microbial quality of the harvested rainwater was investigated. The results obtained indicated that the chemical quality of the rainwater varied based on the roofing material utilised to construct the catchment system. The type of roofing material is therefore an important consideration when designing a rainwater harvesting system. Future research should thus focus on monitoring the effect of commercially available roof coating materials on the quality of harvested rainwater. During the monitoring period, it was determined that the small- and large-scale (water collected directly from the solar manifold) solar pasteurization systems were able to treat harvested rainwater to within drinking water standards at 71°C and above, however, cations (Zn and As) were detected at levels exceeding the recommended drinking water guidelines and therefore a filtration mechanism for the removal of chemical contaminants may need to be included in the design of the system.

Cost: R900 000

Term: 2014 – 2017

Programme 3: Drinking water quality

Emerging contaminants in wastewater treated for direct potable re-use: the human health risk priorities in South Africa

Chris Swartz Water Utilisation Engineers; CSIR; University of the Western Cape

2369

Wastewater reuse acts as a possible exposure pathway to a high number of emerging contaminants and their metabolites. A portfolio of treatment options is available to mitigate water quality issues in reclaimed water. However, most municipal wastewater treatment plants are not specifically designed to deal with the emerging contaminants found in wastewater. Many of these compounds may pass through conventional wastewater treatment systems without removal and accumulate in potable water supplies. Thus, there is uncertainty over the magnitude of risk of human exposure to emerging contaminants of concern in wastewater treated for direct potable reuse. There is also a need to study the health-based targets, water quality monitoring and the dynamics and requirements for social acceptance of direct potable reuse in order to ensure successful implementation and long-term sustainability of such projects. The possible presence of emerging contaminants in reclaimed municipal wastewater is of critical concern because of potential adverse impacts to human health. Specific health effect criteria in the evaluation of water recycling for human consumption include: (i) primary health concerns of wastewater reuse

that are the long-term health outcomes of ingesting chemical contaminants found in recycled water, (ii) health risks of using recycled water as a potable water supply compared against similar risk of using conventional water supplies, and (iii) the need for extensive toxicity programmes. This project was undertaken to identify the emerging contaminants of concern in reclaimed potable water, their sources, pathways and receptors, potential risk from exposure to these chemicals, performance of water reclamation treatment systems for removal of these chemicals, and risks for potable water reuse. It included the development of guidelines for implementation of barriers, monitoring programmes and assessment programmes to eliminate or minimise these risks.

Cost: R1 500 000

Term 2014 – 2016

Programme 4:

Water distribution and distribution systems

Interpretation of logging results as a water distribution system management tool

WRP Consulting Engineers (Pty) Ltd

1124

Operational problems in municipal water networks can in some cases be difficult and time consuming to resolve. Such problems can include, but are not limited to, areas with unexplained high or low water pressure, areas with erratic/fluctuating pressures, reservoirs that either run dry or overflow or unexplained connections

between two apparent discrete pressure zones. Few municipalities are equipped to resolve such problems quickly and efficiently. In many municipalities, the problem is also exacerbated by insufficient personnel and budgets for operation and maintenance. Operational staff should be equipped to identify and resolve water-related operational problems quickly and efficiently. This will assist in improving customer satisfaction, prolong infrastructure life and reduce water wastage. This report provides a guideline for municipalities to identify and resolve a number of different operational problems (in water reticulation systems) through logging of pressures and flows and the interpretation of those logging results.

Cost: R300 000

Term: 2016 – 2017

The effect of age on the friction of large diameter potable water cement mortar lined pipelines

University of KwaZulu-Natal (Howard College); Umgeni Water

2372

The change in roughness of water distribution pipelines is important and influenced by many factors such as tuberculation, sedimentation, biofilm growth, etc. These factors depend on a number of parameters such as water quality, flow characteristics, pipe materials and age, and temperature. Improved quantification and identification of these factors requires further investigation, reviewing the available literature, conducting experimental investigations, performing field investigations, and



developing models/software that will assist designers in evaluating a pipeline system over its full life cycle. Previous studies have shown that biofilm, aggregates of cells of polymeric substances which grow on the pipe wall, affects the friction factor as well as lifespan of pipe networks. The rate of bacterial attachment, growth and death are dependent on chlorine and chloramines present, water quality, pipe materials and lining, flow characteristics and temperature. The study focused on studying biofilm processes, with various disinfectant concentrations, for polyvinyl chloride and cement mortar lined water distribution pipeline materials, and developing a mathematical relationship relating friction

factor and other hydraulic parameters. This study demonstrates the relation between biomass/film growth and roughness or friction using shear stress profiles. Though the results suggest that biofilm formation is expected to be slowest in regions of high velocity, these results were obtained under laboratory conditions where a number of factors were controlled. A higher velocity producing higher stress may kill more mature biofilms, but it may not be easy to detach young, thin biofilms even by increasing the velocity.

Cost: R354 000

Term: 2014 – 2016

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1:

Emerging treatment technologies – Preparing for the future

Integrating agriculture in designing low-cost sanitation technologies in social housing schemes: a case study of Kwadinabakubo, eThekweni Municipality

University of KwaZulu-Natal (Pietermaritzburg);
eThekweni Municipality; Bremen Overseas Research and Development Agency

2220

The aim of this project was to generate information on recycling of nutrients from DEWATS technology and other human excreta-derived materials (HEDM) that will

inform policymakers and town planners in the design of new social housing developments that include an agricultural component. The specific objectives were

- To identify suitable agricultural areas in terms of liquid loading capacity, soil and climatic variables
- To evaluate the effect of wastewater use on soils and crop production, including risks of microbial contamination
- To assess the quality of wastewater and its effects on the environment
- To generate information that could be used to develop protocols that integrate agriculture in social housing development schemes

These objectives were achieved through field, tunnel and laboratory activities that focused on the 'nutrient uptake' aspect, with some attempt at achieving nutrient balances and thus estimate of nutrient loss. The soil processes that govern the two most critical elements in human waste for both plant growth and possible environmental problems, namely nitrogen (N) and phosphorus (P), were the main focus. This involved their behaviour when applied in liquid (effluent) and solid (HEDM) form. Effluent application considered both the nutrient and water demands of the crops as opposed to the solid waste which concentrated on the former aspect. Other critical aspects of these materials examined were their pathogen content and their behaviour in soil as well as their acceptability for use by the target communities.

Cost: R1 880 000

Term: 2013 – 2016

Programme 2:

Application of appropriate technologies and tools

An investigation into the barriers to implementation of effective wastewater charges by municipalities in South Africa

Prime Africa Consultants cc

2210

Wastewater treatment (WWT) services are one of the core business responsibilities of a municipality. Legislation in South Africa ensures access to water services, affordably and effectively, to all consumers, in an economical and

sustainable manner. The approach for setting an effective wastewater treatment tariff is challenging because it requires coordination of activities across multiple municipal departments and the setting of an effective tariff requires a long-term perspective. Fundamentally, a wastewater tariff set by a municipality needs to cover all costs associated with the treatment of wastewater to an appropriate environmental standard. The barriers to the implementation of effective wastewater treatment charges by municipalities were investigated through consultation with key stakeholders from the public and private sector through surveys, a national workshop and interviews. The main barriers identified included cost accounting, ring-fencing, asset management, human resources and knowledge of the client base. At some municipalities, the costs associated with WWT service provision are not separated from other municipal expenses and revenue generated from WWT services provisioned are not entirely reallocated to fund WWT capital and operating expenditure. Many municipalities found it difficult to account for assets and make provision for maintenance and replacement. Furthermore, insufficient information on the client base makes the mandate of differentiating between types of water service users to ensure social equity difficult. An overarching barrier to these goals is the insufficient human resource capacity to address these issues.

Cost: R1 243 500

Term: 2013-2016



The contribution of WRC research to sustainable municipal wastewater and sanitation services

Sarah Slabbert Associates

2476

This study investigated the knowledge needs of municipal officials as a way of providing the WRC with insight into how their research products rate in terms of awareness, uptake and impact within the municipal environment and hence the contribution that these products make to sustainable wastewater and sanitation services. This was achieved through an assessment of the following;

- Uptake and impact of the WRC research products in wastewater and sanitation services
- Factors shaping use of research-based knowledge in the municipal environment; and success stories and existing opportunities
- The main study findings suggest the need to address, inter alia, the following;
- Promotion and fostering of partnerships amongst key stakeholders within the wastewater research sector
- Creation of a culture of knowledge sharing and mentorship within municipalities
- Development of more effective dissemination mechanisms that promote better uptake of current knowledge products, particularly by rural municipalities
- Creation of forums/platforms that bring the municipal community together for active interaction in addressing their daily operational challenges
- Driving awareness of the WRC and its knowledge products within municipal environments through a robust marketing and communication drive

Cost: R750 000

Term: 2015 – 2016

Programme 4:

Wastewater sludge and faecal sludge management

Development of the Anaerobic Digestion and Pasteurisation Treatment (ADAPT) concept for the safe disposal and beneficiation of faecal sludge

Rhodes University

2306

This research project fell under the umbrella of the larger programme known as the Sanitation Research Fund for Africa (SRFA), which seeks to build capacity and stimulate innovation in faecal sludge management on the African continent. The purpose of this study was to evaluate the potential for the beneficiation of faecal sludge from ventilated improved pit latrines (VIPs) through treatment in a hybridised anaerobic digestion and pasteurisation (ADAPT) system with biogas, generated from the anaerobic process, used for heat sterilisation purposes. VIP toilets in the Eastern Cape Province were emptied and the faecal sludge treated in a laboratory-scale reactor. Early laboratory results indicated that the faecal sludge generated from the digestion process not sufficient to sustain the pasteurisation process. In order to increase biogas output, the co-digestion of faecal sludge with other organic feeds was evaluated. A series of bench-top experiments were performed using Schott bottles as mini anaerobic digesters to determine the most suitable organic

co-feed to improve biogas output. Algae were found to be a most useful co-feed, but for practical purposes, anaerobic digester sludge from a wastewater treatment works was used as this was easily accessible. Generation of a combustible biogas was demonstrated in this study, but the greatest difficulty reported was preventing biogas leakages and storing captured biogas. Nevertheless, the potential for generating biogas for pasteurisation was demonstrated, although augmentation with liquid petroleum gas is a likely prospect in a commercial process. Pasteurisation efficiency can be enhanced by insulating the sides of the pasteurisation vessel. Further design work needs to be carried out to reach the optimal insulation of the vessel. Pasteurisation was shown to be effective in eliminating the threat of selected bacterial pathogens; however, the effectivity against helminths is moot. With one exception, no helminths were detected in the faecal sludge samples. A metagenomic study was carried out over seven pits where different depths in the latrine pit were sampled in order to better understand the biological processes that occur in latrine pits. The resolution of the study was poor due to limitations of the reference database, although bacteria typically associated with anaerobic digestion were detected in the samples. However, some bacterial families containing noted pathogens were also identified in sludge samples and indicate consequences for the health of sanitary workers and the surrounding community. Future studies should focus on determining whether these putative pathogens are indeed present in pit latrines.

Cost: R1 180 000

Term: 2013–2015

Towards integrated sanitation and organic waste management – improving faecal sludge management on municipal level by upgrading local wastewater treatment plant with value-added processes (example: Tlokwe Local Municipality)

North-West University (Potchefstroom)

2307

This project fell under a larger programme known as the Sanitation Research Fund for Africa (SRFA) funded by the WRC and the Bill & Melinda Gates Foundation (BMGF). The goals of this project within the SRFA programme were to improve research capacity on faecal sludge management at the North-West University (NWU Potchefstroom campus) and Tlokwe Local Municipality, with emphasis on the co-digestion of organic waste streams with faecal sludge. The specific aim of the project was to establish the feasibility of co-digestion of faecal sludge and other organic sources with municipal sludges at Tlokwe wastewater treatment plant. The research indicated that the co-digestion of ‘fresh’ faecal sludge (top layer sludge) with sewage sludge will neither significantly improve nor impede the biogas or methane yield, making the co-digestion of these substrates an alternative disposal route for faecal sludge. Further, it showed the importance of seeding in the overall digestion process. For the co-digestion disposal route to be effective, an appropriate containment, transport and collection system for faecal sludge has to be implemented to provide relatively fresh sludge.

Cost: R1 050 000

Term: 2013 – 2017



Investigating the practice of open defaecation post-sanitation provision and the practice and implications of ingesting soil which may be contaminated

Partners in Development (Pty) Ltd; University of KwaZulu-Natal (Howard College); University of Venda; North-West University (Mafikeng); South African Water and Sanitation Association

2379

This study was initiated to better understand three common issues that were reported in previous fieldwork studies commissioned by the WRC: realities of open defaecation in relation to basic sanitation infrastructure provision, the practice of geophagia (consumption of soil) and helminthiasis (infection with intestinal parasitic worms). This study sought to understand the beliefs, knowledge, attitudes, practices and consequences associated with these three phenomena and explore the role which open defaecation and geophagia may play in the transmission of helminthic infections and diarrhoeal diseases.

Cost: R750 000

Term: 2014 – 2016

Guiding principles in the design and operation of a full-scale wastewater sludge digestion plant with enhanced CHP generation

Water Group Holdings (Pty) Ltd; City of Johannesburg; Johannesburg Water

2478

The study used City of Johannesburg's full-scale CHP installation as a case study to:

- Provide a practical guideline for the design and operation of a sludge treatment plant, with enhanced CHP generation
- Identify and quantify the opportunities to replicate this approach across the South African industry, at municipal WWTWs which already incorporate anaerobic digestion

In this regard, design principles of the various process units that are involved in sludge processing (sludge thickening, cell lysis, anaerobic digestion, and biogas to electrical energy (CHP), struvite (MAP) recovery, solar drying beds, sludge composting and offsetting of the final biosolids product) were identified, while operational data were collected from the Johannesburg Northern plant, and Olifantsvlei WWTW, for each process step involved in producing, thickening, conditioning, treating and digesting sludge related to biogas production for the CHP system. Performance was analysed for each process unit by considering the sludge quality input to the process unit, the outflow from the unit and the expected design performance of each particular process unit. The hydraulic retention in the anaerobic digesters was identified as an important operating parameter with regard to biogas production and a direct correlation between reduced hydraulic retention and reduced electrical power made. In addition, the lower temperature has a negative knock-on effect on digester efficiency and biogas production and this result in reduced efficiencies. Mapping of anaerobic digestion in

SA indicated that 46 water services authorities (WSAs) (out of 152) have approximately 420 anaerobic digesters, which are spread across 108 WWTWs (out of 824) across 9 provinces, with a corresponding design volume of 1 367 ML. A tool designed to calculate the potential electrical energy at each of the 108 WWTWs with anaerobic digesters estimated an achievement of a total biogas production of 282 671 m³/day, translating to electrical energy of 657 765 kWh/day, with a monetary value of R 144 million/annum at 60 cents/kWh of electricity. The study further offered a model to give practical guidance on the minimum requirements to economically and sustainably develop biogas to energy at a given plant. For the purposes of this study, the 'minimum feasibility requirement' is defined as a CHP project with an assumed lifespan of 15 years that will pay back the investment including financing cost over the project life cycle of 15 years. In this regard, any loading or condition better than the model curve will result in the generation of a positive cash flow over the project life cycle.

Cost: R550 000

Term: 2015 – 2016

Programme 5:

Sanitation technology and innovations

Towards wastewater biorefineries: integrated bioreactor and process design for combined water treatment and resource productivity

University of Cape Town

2380

In this project, the concept of the wastewater biorefinery (WWBR) was investigated, i.e., the integrated processing of a wastewater stream or streams to generate products of value, including 'clean' water, and remediate the effluent simultaneously. The focus has been on both developing and testing this concept as well as evaluating its applicability to and potential in the South African context. In this regard, review of relevant research was done internationally and nationally, presenting extensive literature reviews with regards to the different aspects of WWBR, addressing both the global and local context. This included a review on the wastewater streams available in South Africa, thereby examining some potential products as well as the bioreactors required to produce them. To contextualise the findings in an integrated system, a generic flowsheet and mass balance model was developed and used to explore the features of the integrated biorefinery to assess a few conceptual case studies. The need to integrate multiple unit operations to ensure compliant water as well as produce a bioproduct or bioproducts has been highlighted as key. A model of these integrated unit operations that generates material inventories across the system was developed. This can be used to help to evaluate possible scenarios in an integrated context through the use of a generic flowsheet and mass balances. Consistent data on wastewater has been observed to be lacking. This is the clearest need emerging from this study in terms of assessing the national position, both for the development of the WWBR and for conventional environmental management. There is a need for specification of the approach to data collection, including the manner of measurement, frequency of recording and responsibility



for reporting and collection. The data required, and its form, must be specified. This also includes the development of appropriate instrumentation. This study concluded that the economic considerations around specific WWBR cases cannot be considered in a generic manner, yielding a universal solution, but is dependent on regional locality, product market needs, logistics and other factors at play. A lack of sufficient data to

inform economic decisions is an expected concern at this stage. In terms of further studies, detailed techno-economic studies coupled with integrated pilot studies on a case study basis to provide more insight have been recommended.

Cost: R1 200 000

Term: 2014 – 2016

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 3:

Quantification, prediction and minimisation of water use and waste production

Revision of Natsurv 5: Water and Wastewater Management in the Sorghum and Beer Industry (Edition 2)

University of Pretoria; Tshwane University of Technology
2384

The traditional sorghum beer industry is a beverage industry, and water, sorghum, and energy are essential for its operation. This NATSURV outlines industrial operations, the degree to which resources are managed using a set of indicators per unit of production (e.g. specific water intake), best practices adopted or currently under implementation and, finally, provides recommendations that can improve resource utilisation. A key feature on the changes in this industry since the 1st edition (1989) is its decline, both in number of breweries and volume of beer produced per annum. The annual beer production has

decreased about five-fold as the number of breweries and malting plants declined from 33 and 5 in 1989 to 4 and 1 in 2016, respectively. The average specific water intake and specific effluent volume per unit product have increased, possibly due to closure of bigger plants where the larger production volumes are accompanied by lower per unit water consumption due to economies of scale. The COD, TDS and SS values for the wastewaters showed a reduction compared to 1989. Both the annual water usage and effluent generated (total volumes) have decreased. Overall, with the ongoing process of improving the sorghum beer industry through modernization (e.g. automation of certain processes) and incorporation of best practices such as using cleaning-in-place (CIP), and adoption of stringent accounting systems for process resources, it is likely that the performance of water, energy and waste in this industry will improve considerably.

Cost: R700 000

Term: 2015 – 2016

Revision of Natsurv 6: Water and Wastewater Management in the Edible Oil Industry (Edition 2)

Cape Peninsula University of Technology; Chris Swartz
Water Utilisation Engineers

2404

Manufacturing and processing industries consume significant quantities of energy and water. In addition, unwanted liquid, solid and gaseous waste is generated along with the intended products. Novel, more sustainable methods are constantly being sought to reduce qualitative and quantitative industrial pollutant loads and re-use water and waste. This move is largely in response to a number of interrelated factors, including higher costs of waste disposal, more stringent legislative requirements, and increasing environmental awareness. Between 1986 and 2001, the WRC commissioned 16 national surveys (NATSURVs) of various agri and non-agri industries (malt brewing, poultry, red meat, edible oil (EO), sorghum malt and beer, dairy, sugar, metal finishing, soft drink, tanning and leather finishing, laundry, textile, oil and refining, power generating). This culminated in the publication of 16 separate NATSURV documents, one for each industry. One of these, entitled 'Water and wastewater management in the edible oil industry' (WRC TT-40-89) included information about specific and generic production processes, water usage, solid waste generation, and wastewater quality, quantity and treatment practices in SA EO industry. This new survey serves to update the content of the original document, highlighting the changes which have taken place in the industry over the past two and a half decades. The report includes information stemming from an audit of

the industry from both a local and global perspective. Limited information about the local EO industry was obtained using combined desktop, site-visit, and laboratory-based approaches. In addition to water and wastewater management, the document includes a section on energy audits and adoption/non-adoption of sustainable procedures by the industry at large.

Cost: R750 000

Term: 2014 – 2016

Revision of Natsurv 8: Water and Wastewater Management in the Laundry Industry (Edition 2)

Chris Swartz Water Utilisation Engineers; Cape Peninsula University of Technology

2405

This National Survey (NATSURV) provides an overview of the laundry industry, its changes since the 1980s and its projected changes. It critically evaluates and documents the generic laundry processes in terms of current practice, best practice and cleaner production. We have determined the water consumption and specific water consumption (local and global indicators, targets; benchmarks, diurnal trends) and recommend targets for use, reuse, recycling and technology adoption. We also determined wastewater generation, typical pollutant loads (diurnal trends) and best practice technology adoption. The local electricity, water, and effluent prices and by-laws within which these industries function have been described and evaluated to judge if the trends and indicators are in line with water conservation demand



management and environmental imperatives. The NATSURV evaluates the specific industry water (including wastewater) management processes adopted and provides appropriate recommendations, and the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life-cycle assessments, water footprints, wastewater treatment and reuse, best available technology and ISO 14 000. Finally, we have provided recommendations on the best practice for this industry. The application of water-conservation techniques should enable commercial laundries to have specific water intake of 12–15 L/kg and 1.5–4.5 L/kg for washer-extractors and continuous batch washers, respectively. Water consumption must be accurately monitored and ultimately compared with theoretical, programmed water use. When the comparison reveals that more water is used than required, it will then be possible to start identifying causes. Economic and simple wastewater treatment processes should be reviewed and implemented first before considering more sophisticated options. Emphasis is placed on the control of pH and the removal of solids. The control of pH is essential since municipalities generally limit the wastewater they receive to a pH of 5–9. Failing to adhere to this range incurs a charge to the laundry. The highly alkaline wastewater generated by commercial laundries can be treated with an acidifying chemical. The only solids in laundry wastewater are colloidal, or tiny suspended particles. Colloidal solids will not settle out unaided so coagulation and flocculation chemicals can be added to assist in the sedimentation process. For a relatively small capital outlay for a settling tank and some chemical dosing equipment, a considerable improvement in the quality of

the wastewater can be expected, with concurrent savings in municipal wastewater treatment charges. For further treatment of laundry wastewaters, perhaps for reuse of rinse water as well as wash water, more sophisticated treatments may be necessary. These processes are all capital intensive and would only be worth considering as a second stage after simple wastewater treatment and management measures had been implemented.

Cost: R700 000

Term: 2014 – 2016

Revision of Natsurv 12: Water and Wastewater Management in the Pulp and Paper Industry (Edition 2)

Water Group Holdings (Pty) Ltd; Prodomos Technologies (Pty) Ltd

2421

Twenty-nine paper and pulp mills are operational in South Africa. The bulk of production is performed by the five largest manufacturers, namely Kimberly-Clark, Mondi, Mpact, Sappi and Twinsaver Group. These companies operate 15 mills of which 8 are paper and pulp mills and the remaining 5 are paper mills. The study included 11 independent tissue manufacturers and 3 independent packaging material manufacturers in this sector. The big manufacturers, as well as the independent packaging material manufacturers, participated fully in the study. Raw water intake to the manufacturing process is usually derived from a water resource where the abstraction is authorised by the Department of Water and Sanitation, or from the local municipality. The specific water intake (SWI) for the 22

participating sites varied between 3.5 and 76.1 m³/t. For the paper and pulp mills the SWI varied between 11.9 and 76.1 m³/t and for paper mills between 3.5 and 38.8 m³/t. This represented a marked decrease from the 1990 edition which reported 33–136 m³/t for paper and pulp mills and 1–49 m³/t for paper mills. Different volumes and quality of wastewater are produced during the manufacturing processes. Effluents are treated via a range of treatment technologies which include clarification, activated sludge, dissolved air floatation and belt presses. The treated effluents are discharged to the receiving environment or reused/recycled to the manufacturing process where technically feasible. The specific effluent volume (SEV) generated varied between 0.08 and 84.5 m³/t. For paper and pulp mills the SEV varied between 10.5 and 84.5 m³/t and for paper mills between 0.08 and 38.2 m³/t. The variations between water intake and effluent generation are a function of a range of factors such as feed material used, technology selection, product produced and the age of the facility. A comparison of the 1st and 2nd edition (1990 vs. 2015) shows that:

- A larger sample of mills participated in the 2015 survey than in 1990
- Differentiation between integrated paper and pulp mills and non-integrated paper mills was added to the 2015 survey
- Average SWI decreased from 40.0 m³/t to 25.2 m³/t and the maximum SWI decreased from 136 to 76.1
- Average SEV decreased from 28.6 m³/t to 22.8 m³/t and the maximum SEV decreased from 103 to 84.5
- Average and maximum COD, conductivity and SS levels have decreased
-

The reduction in SWI and SEV is a reflection of actions taken by the industry to recover and re-use water, thereby reducing freshwater intake. This awareness was confirmed by the improvement in effluent treatment technologies and equipment at a number of the sites surveyed. The use of water footprinting and risk management were key considerations when undertaking facility expansion studies and selecting appropriate technologies. Increasing electricity costs and the damaging impact of load-shedding has also resulted in and increased energy awareness across the industry. The data indicate that the South African paper and pulp industry is performing on par or exceeding international standards. The generation of renewable energy from waste products is a consideration at larger sites and has already been incorporated at some of the plants. Specific energy consumption (SEC) ranges from 1.6 to 6.3 GJ/ADt, as Eskom electricity. Total SEC ranges for 3.7 to 11.3 GJ/ADt) which includes Eskom electricity, steam, renewable/recoverable energy, coal to steam and gas. The industry is extensively regulated through the application of national legislation (in particular water use authorisations), municipal trade-effluent bylaws, as well as national and international norms and standards such as ISO and SANS. The study shares perspectives by the industry and the regulatory authorities pertaining to the use of water and effluent targets and compliance with norms, standards and specifications.

Cost: R850 000

Term: 2014 – 2017



Revision of Natsurv 17: Water and Wastewater Management in the Steel Industry (Edition 1)

Water Group Holdings (Pty) Ltd; Prodomos Technologies (Pty) Ltd

2422

The purpose of the NATSURV 20 Study is to review the status of the South African iron and steel industry with specific focus on national production capacity, specific water intake and effluent volumes, specific energy consumption rates and best practices in the management of water and effluent. The study includes an evaluation of the most pertinent legislation that regulates the industry on national and local levels. Five companies operate iron and steel mills in South Africa. One of these companies declined to participate, with the other four providing information to different levels of completeness. Due to the severe economic pressure in this sector, one of the four companies went into business rescue procedures and another entered a round of retrenchments with the result that these two companies could not provide all requested information due to limited resource availability. Thus only a limited amount of data are available. Raw water intake to the manufacturing process is usually derived from a water resource where the abstraction is authorised by the Department of Water and Sanitation, or from the local municipality. The specific water intake (SWI) for the four sites for which data were received varied between 2.3 and 9.3 m³/t. The specific effluent volume (SEV) generated varied between 0.9 and 3.6 m³/t. Different volumes and quality of wastewater (effluent) are produced during the manufacturing processes. Effluents are treated via a range of treatment technologies

which include clarification, activated sludge, dissolved air floatation and evaporation. The treated effluent is discharged to the receiving environment or reused/ recycled to the manufacturing process where technically feasible. The variation between water intake and effluent generation is a function of a range of factors such as age of facility, technology selection and product produced. Depending on the product range, the concentration of various metals used on site are also monitored. Energy awareness has also grown in the industry, both as a result of increasing electricity costs as well as due to the detrimental effect of load-shedding. The study found that the industry is extensively regulated through national legislation (in particular water use authorisations), municipal trade-effluent bylaws, as well as national and international norms and standards such as ISO and SANS. The study shares perspectives by the industry and the regulator pertaining to the use of water and effluent targets and compliance with norms, standards and specifications. It is recommended that continuous improvement focusing on improved SWI and SEV target continue to be used in this industry; and that research continues to explore the energy and resource recovery potential associated with the industry.

Cost: R850 000

Term: 2014 – 2017

Programme 5:

Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Nanoparticles for the treatment of industrial-scale effluents – particularly the removal of organic contaminants from textile effluents using nano-TiO₂

Cape Peninsula University of Technology; Atl-Hydro; University of Fort Hare; University of Johannesburg
2386

The textile industry is one of the most chemically intensive industries on earth, using more than 100 000 types of chemicals and the number-one polluter of potentially potable water internationally. The aim of this project was to assess the application of one of the emerging nanotechnologies for water treatment, namely, nanofiltration and nanophotocatalytic treatment of the nanofilter retentate. The objectives of this work were:

- To conduct a stream segregation scoping assessment and a cleaner production effluent audit for a proposed wastewater treatment process at the Falke Eurosocks
- To design, build and evaluate a pilot-scale rig for the treatment of textile effluent using pre-filtration, ultrafiltration and nanofiltration
- To develop synthesis strategies for production of controlled sized titanium dioxide nanophotocatalyst powders
- To develop and optimize technology to treat effluent using immobilised titanium dioxide nanoparticles under daylight in a trickle-bed reactor
- To evaluate the performance of the nanofiltration

and photocatalysis of real textile effluent; this report presents results for the treatment of commercial textile effluents using nanofiltration and photocatalysis using nano-titanium dioxide

The stream segregation audit revealed that the installation of three-way valves into the existing piping systems can easily facilitate separation of waste streams for treatment and reuse. Boiler water and condensate can be treated and separated from the dye vat effluents. This will reduce the footprint of the final effluent treatment plant.

Several strategies were developed for the local production of nano-titanium dioxide powders for use in photocatalysis. Existing sol-gel methods were improved. Robust process conditions were established for the production of sub-10 nm particles using continuous hydrothermal synthesis to produce multi-polymorph anatase-rich nano-titanium dioxide. These results are very encouraging showing the possibilities for locally manufactured photocatalysts to be used in the treatment of textile effluents. Various methods of immobilising nano-titanium dioxide were evaluated. The industrial potential for the utilisation of the nano-titanium dioxide immobilisation techniques developed in this work is great since there is a nanofibre spinning company in Cape Town able to produce large mats that could be incorporated in a multistage thin film fixed bed photocatalytic reactor for upscaling of the process using artificial and/or natural sunlight. An ultrafiltration/nanofiltration pilot effluent treatment plant was designed and installed at the factory. Under the current conditions, 50% of water could be recovered as the nanofiltration



permeate. The colour was successfully removed from the nanofiltration brine during treatment using standard conditions under which the sample was only treated for 90 minutes; if treatment time is increased, further removal of COD and TOC could be achieved. The inorganic ions can be recovered during a further treatment step.

Cost: R1 250 000

Term: 2014 – 2016

CURRENT PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1:

Cost-recovery in water services

Development of innovative institutional management scenarios for water services in rural areas

PDG

2209

Rural water supply challenges continue to prevent South Africa from achieving basic service provision to all. While many of the challenges are technical (topography, geography, technology), the dominant obstacle to successful rural water service delivery is finding an institutional model(s) that complements local government as Water Services Authorities and can (i) overcome these technical challenges, (ii) manage scarce resources in an efficient manner, and (iii) provide a continuous and sustainable service. This project seeks to review the available institutional management options for rural water services, as well as introduce possible alternative and innovative management solutions. While many of these models have been debated and assessed before, there has been limited success with these models in South Africa. The study also seeks to go beyond regulatory and technical aspects, and cover a spectrum of socio-political dynamics, economics, and culture, as well as investigate a wider range of potential institutional partners (Water User Associations, mines, etc.). This is

particularly relevant given that the DWA Institutional Reform and Re-Alignment process has highlighted the institutional gap around the management of local water resources.

Cost: R1 620 113

Term: 2013 – 2015

Revising the DWA guidelines on municipal tariffs for water services

Nelson Mandela Metropolitan University

2356

In their capacity as the policy leader for Water Services Authorities and Providers (WSAs and WSPs) in South Africa, the South African Department of Water Affairs (DWA, now the Department of Water and Sanitation, Department of Water and Sanitation) have issued guidelines for financial and water services managers involved in setting retail water and sanitation tariffs for standardised piped water service packages; the most recent of which were issued in 2011 (DWA, 2011). The guidelines favour a homogeneity in water service delivery package (a similar quality of piped water service for rich and poor), retail tariff setting to recover the on-going capital and operating costs, a distinction between potable water provision and waste water management



(sanitation) services, and retail tariff structures comprised of one or two parts, customised to several different categories of user demand. One part of the tariff structure is related to usage and another to access (and is fixed). The guidelines recommend that the part of tariffs related to usage should rise in incremental steps as household demand does, that is, an increasing (and therefore also non-linear) block tariff (IBT) structure. Not only is a water service tariff structure the key element in raising revenue to offset the costs incurred in provision, it also is a key element in allocating water services provided, and influences a wide range of choices and decisions, many of which are closely linked to local and regional economic development. South African water tariffs are not set endogenously through the interaction of demand and supply, so automatically taking into account a whole range market influences, but within a constitutionally mandated monopoly market setting. As a result setting water service tariffs has largely become a municipal discretion. It is a discretion that requires some negotiation, but also permits a wide range of options, e.g., choosing a water service provider (or composite of firms that will supply), choosing what water service packages will be offered and choosing the revenue-raising mechanisms that will be employed to recover costs. It is also a discretion that can benefit by more informed guidance. This research will provide a context and framework for this discretion to be exercised.

Cost: R1 600 000

Term: 2014 – 2017

Exploring opportunities for domestic-local investment in water and sanitation services – challenges and constraints

African Centre for a Green Economy (Africege); University of Cape Town; University of the Western Cape; Cape Peninsula University of Technology; Crossflow Consulting (Pty) Ltd

2484

Significant effort by the South African government has gone into mobilizing resources to meet service delivery targets. Most of the resources directed to funding water and sanitation infrastructure have come from Government capital grants for new infrastructure and operating grants to support service delivery to poor households and for free basic water. Despite the substantial investments, major backlogs in service delivery still remain in many parts of the country, especially in rural and township areas. This has been compounded by other socio-economic challenges and has given rise to the prevalence of service delivery protests throughout the country, with major implications for the productivity of the South African economy. Many developing country governments and the international development community are looking for ways to accelerate access to improved water and sanitation services beyond the Millennium Development Goal (MDG) targets. Many countries do not have the capacity to meet the need for improved water supplies and sanitation services from public resources alone. This is also the case in South Africa, where the fiscus is the main source of funding and there is great dependency on it to close the backlogs quickly. These challenges present an

opportunity for domestic enterprises in these growing markets. The domestic investment sector is increasingly being viewed as a central part of the solution. Effective scale-up of access through the domestic investment sector requires an understanding of the market potential, the state of entrepreneurs' operations, and factors that shape their business environment and investment decisions. This study will examine the investment sector's support to piped water services and sanitation services. It will cover aspects of policy, legislation, constraints and challenges, as well as models to facilitate or enable participation. The outcomes of this project relate directly to the Government's mandate to deliver basic services to its citizenry, in an efficient, inclusive and effective manner, as defined in various policy documents including the Water Services Act and the National Development Plan (NDP).

Cost: R800 000

Term: 2015 – 2017

Programme 2:

Institutional and management issues – Water services

Constraints on providing sewerage in South African informal settlements: A study of social and institutional management concerns

University of Cape Town; City of Cape Town

2120

This study presents evidence, based on ethnographic research focused on the provision of janitorial services in

three informal settlements (two in Cape Town and one in Overstrand). The specific aims of the study were to interrogate the introduction and/or provision of janitorial services in public flush toilet facilities in three Western Cape informal settlements, which meant documenting, analysing and understanding imperatives for and obstacles to providing and managing public flush toilets in informal settlements. Key findings from the research indicated that all role-players involved in using and/or providing informal settlement municipally-provided sanitation services:

- Experience health and safety risks which led to their being fearful and which affected their access (i.e. having the right to enter, get near, or make use of something) to toilets/sites
- Experience difficulty reliably coordinating the various interests/processes associated with cleaning/managing sanitation services
- Have diverse and thus different expectations of what constitutes a free basic sanitation service, and of what should comprise the associated responsibilities of users and of various kinds of service providers
- Influence municipal policy through practice
- Experience lack of guidance from national policymakers when providing services for informal settlements

In addition:

- Municipal incapacity and inflexible institutional processes that impede effective service delivery
- Residents' alternative sanitation practices negate the aims of the state's Free Basic Sanitation strategy
- Officials tended to set-up, in preference, centrally-administered and standardized systems, whilst



janitors and residents preferred to have initiatives that were tailored especially to their particular situations

- Municipal authorities and contracted workers (e.g. service providers and janitors) are held legally accountable/responsible for delegated tasks, whereas resident users cannot be legally bound to fulfill O&M responsibilities.
- 'Public' janitorial services are generally more effective/reliable than 'community' systems in informal settlements because:
 - » Officials and residents had similar expectations of who could access the facilities and who is responsible for the services
 - » Despite being under-resourced, municipalities seemed better equipped than residents to manage cleaning services

Cost: R1 000 000

Term: 2012 – 2014

An investigation into the social, institutional and economic implications of reusing reclaimed wastewater for domestic application in South Africa

Cape Peninsula University of Technology

2208

This study is situated in the context of the social and environmental problems South Africa will be facing over the next five years. With the effects of climate change and depletion of the current water resources, alternative water supply such as reuse is becoming common. Experience at Windhoek demonstrates that a direct wastewater

reclamation system can be a practical, responsible way of augmenting potable water supplies in arid regions, but requires comprehensive planning, training and ongoing commitment for its continued success. National and local policies should support reuse of wastewater, taking the constraints of the region as well as the potential threats of wastewater reuse into consideration. Active participation through educational programmes is needed to encourage planners and engineers to design systems that cater for reuse or that can at any time be changed to a reuse scheme. Despite people's acknowledgement of the water scarcity of their countries, it is found that the general public in most communities has little knowledge of its water and wastewater treatment and distribution systems. To gain public acceptance of direct reuse of reclaimed wastewater, experts (including engineers, scientists and physicians) should agree that reclaimed wastewater is safe to use from a public health standpoint. In addition to this, the list of promoting factors such as water shortage, gradual introduction of water reuse, and agreement amongst experts should be brought forward. Current literature, with the exception of work on Australia, seems to be almost silent on community awareness and/or engagement on the issue of using wastewater for reclamation. This need to engage communities is a principle enshrined within the South African Constitution and is reiterated in the water service regulation strategy, which emphasises the need for a citizens' voice. The lack of understanding or underestimation of this need cannot be more vividly illustrated than by the numerous service delivery protests riddling South Africa, stemming from community experiences and perceptions of unsatisfactory, inefficient service delivery, with drinking water quality

being no exception. The results of this project will assist the government and its various services with an understanding of the implications of using treating wastewater effluent for drinking and its consequences from social, economic and institutional perspectives.

Cost: R1 180 000

Term: 2013 – 2016

Loss aversion and water conservation

University of Cape Town

2357

As a water-scarce country, South Africa must apply its available water resources in the most efficient and equitable manner possible. In its Water for Growth and Development Plan, identifying water scarcity in major urban centres, the Department of Water and Sanitation has highlighted the importance of water conservation and demand management and, specifically, 'nurturing attitudinal and behavioural changes towards the value of water' Through low-cost and non-pecuniary measures, this project aims to make the 'value of water' salient (explicit) to residential consumers, thereby shifting behaviour towards greater water efficiency. To do so, this study proposes to use insights from behavioural economics to incentivize a reduction in residential water consumption. The study will examine whether the behavioural insight that people are loss averse can be exploited by simple gain/loss framing variations. The behavioural literature shows that individuals are very susceptible to framing and that changing the way

we frame options and outcomes can affect individuals' decisions. An outcome of the project will be a clearer understanding of what type of framing most effectively facilitates a behavioural shift towards more efficient water usage and whether it is helpful to make the link between metrics like 'litres used and not used' and 'financial cost and saving' very explicit. Given that these are low-cost interventions, the results from this proposed experiment (for example how to frame messages to consumers) can be incorporated in existing and future information-provision and environmental-awareness campaigns.

Cost: R642 537

Term: 2014 – 2017

Review of urban sanitation in South Africa – challenges and constraints

Palmer Development Group

2486

Almost half of South Africa's population lives in urban areas and their need for safe sanitation and wastewater management services is growing rapidly. Beginning in 2000, the central government embarked on a series of initiatives to reform water supply and sanitation sector policies. These reforms were aligned with decentralization which devolved responsibility for sanitation to the local government. Despite these initiatives, urban sanitation continues to perform inadequately and faces critical issues that need to be urgently addressed. There is a tendency for many planners and designers to wait for large sums of



investment, driven by issues of compliance and political pressure, and thus to respond with conventional solutions. Often these are not affordable to the users or the municipalities. A radical new approach is required, incorporating elements of the water–energy–food nexus together with water-sensitive urban design. It is hoped that the review will develop a strategic framework to help guide national urban sanitation programmes and their implementation in growing urban areas. This study aims to provide a review of urban sanitation in South Africa.

Cost: R594 839

Term: 2015 – 2017

Developing innovative approaches to national allocations and transfers to local government

Palmer Development Group

2487

Recently new innovative systems of grants have been experienced in a number of countries, some of these targeting the performance of local government. SALGA, CoGTA, the Presidency and Treasury are currently busy with the review of national allocation and transfers to local government and in the process are trying to establish the effectiveness of the current processes. It is envisaged that this initiative will lead or require the development of new approaches and processes, based on local circumstances and international best practices. This study will build on this progress and establish new mechanisms and solutions.

Cost: R652 800

Term: 2015 – 2017

Assessing the impact of a mobile application in monitoring water consumption and leak detection at household level

University of Cape Town; City of Cape Town

2485

In recent years, demand-side management of water has gained much research interest, mainly because of steadily increasing populations that have driven an increase in demand for our limited freshwater resources. There is a growing recognition that water resource managers must shift their focus from production and supply to finding ways of reducing user demand. In order for water conservation participation to increase in homes the water users must have easy access to information. Many water users lack knowledge to manage their water demand and are therefore often unable to engage in a discourse with the municipality. Metering is an incentive to engage consumers in water demand management by improving their knowledge about their water consumption. However, it is currently under-utilised in this respect and future research could explore innovative methods to allow consumers to access information about their daily water use. This project intends to assess the impact of a mobile application (called 'Drop Drop') that is designed to allow households to monitor their water consumption by reading their meter and to assist them in leak detection. The application also provides invoice prediction and a simple communication tool to

contact the relevant departments in the municipality. The hypothesis is that providing water users with real-time information about their water use increases their ability to monitor consumption and manage their water demand. The investigation will increase the knowledge base on how personalized water supply information can change consumer perceptions of water usage and increase the level of knowledge as well as trust in the billing system. Part of the project will also be to assess how we can develop mobile applications that are immediately usable without extensive training or documentation.

Cost: R500 000

Term: 2015 – 2017

Programme 3:

Innovative management arrangements - Rural water supply

Dealing with land tenure and tenancy challenges in water and sanitation services delivery in South Africa: Policy options and opportunities

University of the Western Cape

2358

Amid rapid urbanization in South Africa, the challenges of tenure and tenancy seem to detract from the efficacy of on-going efforts to improve access to urban water and sanitation services for the urban poor and marginalized. The proportion of people without sustainable access to safe drinking water and basic sanitation, a significant proportion of people living under complex mixes of formal and informal tenure arrangements in low- and

middle-income areas, continue to cope with water insecurity or express dissatisfaction about water and sanitation service. Although there is a paucity of reliable data on the burgeoning of populations in urban informal economies and, therefore, achievements in access to water and sanitation, it is plausible that this growth may have exacerbated service delivery backlogs and probably reversed some of the gains made towards progressive realization of the access right to water and sanitation. Challenges such as these underscore the need for in-depth review, empirical and action research to develop clear understanding of the ways in which tenure and tenancy affect access to water and sanitation services, particularly for the urban poor, informal tenants and informal settlement dwellers, whose needs for improved services tend to be greater than those of other groups of people living in urban areas. Some of the pertinent research questions are: How is the mix of land tenure and tenancy arrangements within and/or outside the ambit of the formal land registry system characterised, and what is its effect on access to and provision of water and sanitation services. To what extent do current pro-poor service provision strategies take differences in tenure and tenancy profiles into account? How do tenure security and tenancy arrangements affect patterns of access to and investments in water and sanitation services? What are the appropriate service models for different tenure and tenancy profiles? What is the role of formal and informal service providers in this regard, and how can stakeholders, such as the state, non-governmental organizations (NGOs), civil society organisations (CSOs) and the private sector, support this? In the context of rapid urbanization, clear understanding of complexities



associated with the mix of formal and informal tenure and tenancy challenges will contribute to enhancing institutional preparedness and mechanisms to improve access to water and sanitation by the urban poor, marginalized and vulnerable living in low- and middle-income areas. Ultimately, the impacts of this should be social integration, as opposed to fragmentation, as well as better quality of life, dignity, affirmation, enhanced social capacity and well-being.

Cost: R1 890 000

Term: 2014 – 2017

Programme 4:

Programme 4: Regulation of water services

Extending performance monitoring and analysis in South Africa

Nelson Mandela Metropolitan University

2359

There is much that has been achieved in the monitoring of municipal service performance through Blue Drop and Green Drop ratings. It is also being demonstrated in WRC Project K5/2118 (ongoing) that relative efficiency can also readily be monitored and cost-efficiency indices calculated by applying stochastic frontier analysis (SFA) and data envelopment analysis (DEA). The initial findings of relative efficiency analysis for a significant sample of South African municipalities were presented for the first time at a WRC-SALGA National Seminar. At this seminar a number of challenges were raised about the

relative efficiency monitoring. This proposal motivates addressing selected challenges as well as adding in to overall performance assessment a measure for rating consumer satisfaction. Many have expressed concerns with all forms of performance monitoring in South Africa on the grounds that the data is unreliable. Specifically with respect to relative efficiency benchmarking the concern is that the water service outputs reported were less than what was really being delivered, for instance, that large chunks of the service were, in fact, not operational for substantial periods and that this inflated efficiency ratings. In order to address this concern and preserve the integrity of the results, some form of data audit is required. All of the current performance ratings applied or proposed are supply-side ones. The demand-side ratings are missing in South African municipal water service performance assessment. This shortcoming can be addressed through a consumer satisfaction rating, capable of assessing different components/attributes of the service and likely to be relatively immune to strategic bias and political and bureaucratic manipulation.

Cost: R850 000

Term: 2014 – 2016

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1:

Drinking water treatment technology

Development and testing of novel metal-modified natural clay-based adsorbents for groundwater defluoridation

University of Venda

2363

Groundwater is the most appropriate and widely used source of drinking water for many rural communities in South Africa. However, the presence of fluoride concentrations above the recommended limits for drinking water requires defluoridation. A number of methods for removing fluoride from groundwater have been developed, including chemical precipitation, membrane processes, adsorption and ion exchange. Of all these technologies developed so far, adsorption has been considered as the most efficient and applicable technology for fluoride removal from ground and surface water in rural areas. In this study, the development and testing of new or modified adsorbents using locally-available adsorbents with improved fluoride uptake properties, to meet the stringent legislative requirements of 1.5 mg/L of fluoride in drinking water, is explored. The use of locally-available adsorbents for evaluation and application as adsorbents for point-of-use water defluoridation systems for rural areas is a sustainable solution. The potential application of bentonite clay and diatomaceous earth modified with selected high charge

density cations such as Fe^{3+} , Al^{3+} and Mn^{2+} , introduced as metal cations, metal hydroxides/oxy-hydroxides or metal oxides will be tested.

Cost: R690 2000

Term: 2014 – 2017

Functionalized electrospun and cast nanocomposites for the removal of organic matter and bacteria from surface water

University of Johannesburg

2365

Water pollution is a persistent global problem that emanates from increased anthropogenic effects. Polluted water usually contains bacteria, viruses, protozoa, minerals, organic matter and many pollutants in quantities beyond the acceptable limits of water quality standards, therefore requiring treatment before use. Water may be treated using different approaches, depending on the quality of the raw water which enters the plant. Traditionally, adsorbents are used; however, the majority of these suffer drawbacks such as poor pollutant binding capacity as well as weak mechanical strength. In addition, some of these sorbent materials are prone to degradation by chlorine. This study is aimed at the development and evaluation of the potential of fabricated filters for removing organics, metals and micro-organisms from contaminated water.



The proposed filters will have functional multi-layers of electrospun fibres impregnated with nanoparticle catalysts to form nanocomposite filters or membranes. The nanocomposites will be cast onto membranes to produce strong support materials with tailor-made porosity to ensure no passage of water contaminants. This is necessary as the small contaminant moieties that normally resist conventional treatment can be effectively removed because of the functional groups that act as binding sites for contaminants. Owing to their small diameters, high surface area to volume ratio and low porosity, these nanocomposite filters are very efficient in removing most of the water contaminants. The significance of this study will be the ease of use of the multi-layered nanocomposites as well as the disinfection of water without addition of harmful chemicals such as chlorine or labile aluminium.

Cost: R650 000

Term: 2014 – 2017

Solar energy for desalination and water purification

University of Pretoria

2467

Project aims:

- To extend the prior lab testing of the three methods (solar distillation coupled to both a graphitic foam target and a carbon black suspension, as well as a solar evaporator), to small pilot scale, in order to identify possible large-scale implementation issues and assess feasibility

- To compare all three methods and determine which is the most efficient and cost effective for desalination/ brackish water recovery
- To determine which of the three methods will result in the design with the lowest maintenance and operator input

Cost: R500 000

Term: 2015 – 2017

Programme 3: Drinking water quality

Extending EDC Toolbox I to include thyroid and androgenic bioassays

University of Pretoria; Griffith University

2303

Project aims:

- To participate in the Global Water Research Coalition EDC Toolbox
- Inter-laboratory study to establish the suitability and application of the thyroid and androgenic bioassays for the detection of EDC activity in water samples

Cost: R430 000

Term: 2014 – 2016

Nano-membranes hyperbranched polymer integrated system for water remediation

University of Johannesburg; Stellenbosch University

2488

Organic compounds such as chlorinated compounds and phenolic compounds (pesticides) are widespread, mobile, and highly toxic and persistent in the environment. Due to improper disposal and slow degradation rates this has resulted in the accumulation of chlorinated and phenolic organic compounds in the environment. Thus, their removal in the environment using treatment methods such as catalytic degradation has become a priority for water treatment industries. Hyperbranched polymers such as hyperbranched polyethyleneimine (HPEI) have a high number of internal amine functional groups, which can act as ligands to complex metal ions such as Cu, Fe, Ag and Ni for nanoparticle synthesis. Secondly, nanocavities in the HPEI structure act as hosts/templates for the preparation of narrow and stable nanoparticles. Moreover, the nanocavities can act as catalytic and adsorption sites for the degradation and removal of organic pollutants. The hyperbranched structure of the hyperbranched polyethyleneimine also provides a shell to prevent aggregation of the nanoparticles. Lastly, the highly branched peripheral amine functional groups of the HPEI with the bimetallic nanoparticles can be grafted with other molecules such as cyclodextrins, carbon nanotubes and membranes to prepare a new generation of multifunctional material for advanced water treatment applications. Literature studies confirm that materials composed of hyperbranched polymers have rarely been utilised in water treatment and mainly in medical

applications. Thus, there is a great need for further research on these materials in order to broaden their application. Therefore, this project will look at crafting a system that is composed of hyperbranched polymers attached to macromolecules such as carbon nanotubes (for mechanical strength) doped with catalysts such as bimetallic nanoparticles (Fe/Ag, Pd/Fe) or enzymes (lignin peroxidase, manganese peroxidase and laccase) for the effective removal of organic contaminants.

Cost: R600 000

Term: 2015 – 2018

Development and evaluation of a Donnan dialysis process for the recovery and reuse of aluminium from potable water treatment residuals

Stellenbosch University; Durban University of Technology; Cape Town Municipality; Umgeni Water

2470

Aluminium salts, particularly aluminium sulphate (alum) are widely used as a coagulant in large-scale potable water treatment, both internationally as well in South Africa. The precipitated solids from these processes are further dewatered in a filter, yielding an aluminium-rich sludge and a water stream that contains a significant concentration of dissolved Al. At present, the sludge invariably ends up on a land-fill/waste-disposal site, and the destination of the dissolved Al is a river or the sea. It would seem obvious that there would be significant benefits to the costs of water treatment plants, the preservation and optimal use of natural resources, and



the protection of our environment if Al could be recycled and reused. However, whilst there have been concerted efforts to do so over many years, the recycle and reuse of Al have proven to be extremely difficult. Donnan dialysis (DD) is a relatively new technology in the water treatment field. DD uses a cation-exchange membrane, i.e., a membrane that will allow only positively-charged ions to pass through but blocks the passage of negatively-charged and un-charged species. In preliminary work on this topic it was demonstrated that DD was capable of selectively recovering Al, without contamination by organics, from a local WTR. From an engineering point of view the next stage in the development and evaluation of this very promising technology would be to determine the important operating variables that affect the performance of Al recovery, determine how these can be optimized, and hence develop a 'regime map' of the feasible operating regime. From this a 'modular' DD cell can be developed, i.e., a cell which can be replicated and stacked in parallel to process the large volumes that would be required from a real recycling process.

Cost: R1 000 000

Term: 2015 – 2018

Programme 4:

Water distribution and distribution systems

State-of-the-art in advanced metering technology and application

University of Cape Town

2370

The water meter industry has seen substantial developments in the last two decades, with many new capabilities added to water meters. These advanced water meters (also called intelligent or smart meters) can be used for much more than just consumption metering. Advanced meters have several significant advantages, such as saving costs by eliminating conventional meter reading, billing and debt management systems; providing simultaneous readings for multiple users allowing more accurate water balance calculations to be done; assisting poor users to manage their free basic allowance; and enhancing water demand management and water loss control. However, advanced metering systems also have important disadvantages, such as a higher failure rates (due to electronics, batteries and more components) than conventional meters; higher supply and maintenance costs; susceptibility to tampering and vandalism; and concern regarding rights of access to water. It is also a new industry with many teething problems that will still have to be addressed. The aim of this project will be to determine the state-of-the art in developments and application of advanced water metering to allow municipalities to understand the available technology and how best to utilise it. The project is focused on how to use advanced water metering in a sustainable way for providing communities with water supply within the bounds of cost of service provision and limited water resources. A major aim of the project is to assist municipalities with information on decision making regarding advanced water metering.

Cost: R1 280 000

Term: 2014 – 2017

The impact of leak–soil interaction on leak development and detection in water distribution systems

University of Cape Town

2371

Leakage from water distribution systems is a worldwide problem, which is likely to intensify as systems age and available water resources are stretched to their limits. Leaks form in all pipe materials, and thus municipalities must have processes to identify and repair new leaks as they form. The simplest way to find a leak is when it is observed or reported after becoming visible above ground. Other leak detection methods include the monitoring of district metering area flow patterns, analysis of the noise emitted by leaks and inspection of the internal pipe surface. A question that hasn't received much research attention is under what conditions a leak will become visible above the ground. Water distribution pipes are typically buried below meters of graded sandy soils that may facilitate water draining away from the surface. In a recent experimental study, it was found that even jets directed vertically upward did not penetrate about 30 cm of an ideal soil, while sustaining a pressure of 25 m in the pipe. The work showed that a fluidised zone of soil and water is created on the outside of a leak that is responsible for dissipating the vast majority of the energy of the water jet, thus substantially limiting the leak's ability to reach the soil surface. Another implication of the fluidised zone is that the high velocities of the soil particles may cause scouring of the outer pipe surface, especially in pipe materials that don't have much abrasion resistance, such as PVC. Evidence of such

scouring has emerged from failed pipe samples taken from the field, showing that the pipe material is removed by the soil action, eventually increasing the size of the leak. This may cause even small leaks in PVC pipes to eventually become major problems; however, very little research has been done on this phenomenon. Thus, this study will develop an understanding of the fluidisation phenomenon outside leaks in water distribution pipes, and its implications for the development and discoverability of leaks. While the longer-term goal of this work is to develop a theoretical model for the fluidisation phenomenon based on the fundamentals of fluid mechanics, the aim of this project will be to investigate the direct impact on leakage in water distribution systems.

Cost: R700 000

Term: 2014 – 2016

Updating WRC water demand management software for latest operating systems

WRP Consulting Engineers (Pty) Ltd

2373

Since the early 1990s, the WRC has been providing support to municipalities throughout South Africa to address leakage and wastage from reticulation systems. South Africa was one of the first countries outside of the UK to embrace the Burst and Background Estimate (BABE) methodology which was initially developed by a number of experts from various UK water companies. The BENCHLEAK model developed in South Africa was



created to ensure that South African water utilities had free access to software which would encourage the use of the standard IWA water balance. Once again this was the first model of its type and led to the development of many similar models which were used throughout the world. The BENCHLEAK model also helped to promote the concept of the Infrastructure Leakage Index (ILI) throughout southern Africa and in turn led to a large-scale study of ILI values for almost 100 systems countrywide. BABE models developed through the WRC include the original BENCHLEAK water balance model which was initially developed as a simple Excel spreadsheet and has now been superseded by the AquaLite Model. The SANFLOW model used to analyse minimum night flows was one of the WRC's most popular downloads due to its ease of use and simple design. The various models continue to operate properly on some Windows operating systems but not on some of the later systems. It is proposed that the software is re-designed where necessary to accommodate the latest Windows operating systems; the possibility of creating an iPad version should also be investigated. The aims are therefore to upgrade the existing models to ensure that they are fully operational on all current platforms and operating systems. In addition, it is proposed to convert SANFLOW, PRESMAC and AquaLite to run on an iPad and create an app so that they can be downloaded worldwide.

Cost: R520 000

Term: 2014 – 2015

Diversity and dynamics of the microbial population associated with drinking water distribution networks and their impact on drinking water quality

University of Pretoria; Rand Water; University of Glasgow
2469

Water utilities face major challenges in supplying and maintaining safe drinking water to communities. Water leaving the treatment plant is typically of high quality but conditions within the distribution system often lead to deterioration in water quality. Amongst the quality determinants, the microbial quality of the water is typically impacted the most. It is now widely accepted that such studies have focused on only a limited part of the microbial community, and that both the dominant members and some important pathogens may not have been detected. The recent developments in high-throughput sequencing, e.g., 454/Roche or Illumina, and microarray technologies for community analyses, e.g., PhyloChip, during the past few years have opened the door to investigate microbial communities at both species-level resolution and also quantitatively. The proposed study aims to address the following questions based on data collected for a South African network:

- What is the variation in the microbial community present in a distribution system primarily supplied by treated surface water and can the variation be linked to seasonal factors?
- Is the same correlation between the microbial community in the bulk water and the sand filter community observed in a large distribution network where different types of disinfection are practised at different times?

- How homogenous is the microbial community associated with sand filters?
- Are the bacteria involved in nitrification already present in the bulk water directly after treatment and what factors promote their growth within the system?

It is anticipated that answers to these questions will

provide the necessary foundation for the development of a predictive framework and early warning system to manage the microbial quality of drinking water supplied to consumers.

Cost: R900 000

Term: 2015 – 2018

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1:

Emerging treatment technologies – Preparing for the future

Mass balance modelling over wastewater treatment plants III

University of Cape Town; University of KwaZulu-Natal
1822

The series of projects aims to develop a plant-wide wastewater treatment plant (WWTP) model used to accurately predict the outcome of the various biological, physical and chemical processes taking place in a WWTP. These tools can result in more economical wastewater plant design and operation and improved effluent quality. Significant advances have been made towards developing steady state mass balance-based integrated WWTP models which link primary sedimentation, nitrification-denitrification activated sludge and aerobic or anaerobic digestion of primary and waste activated sludges (K5/1338 and K5/1620). This project aims to determine the kinetics of P release from biological

P-removal systems and determine the extent to which mineral precipitation takes place. The P release in anaerobic digestion will be compared to that observed in aerobic digestion. Certain aspects such as the mineral precipitation in aerobic digestion, the un-biodegradable fraction of primary sludge and the un-biodegradable fraction of the waste activated sludge from nitrification-denitrification systems will be confirmed. The research will determine whether the presence of primary sludge will assist in the hydrolysis of waste activated in anaerobic digestion.

Cost: R998 950

Term: 2008 – 2010

Urban effluent treatment in a rhizofiltration system

Durban University of Technology; Stellenbosch University; University of Cape Town

2004



Urban effluent includes stormwater, drainage from informal settlements and townships, sewer overflows, illegal industrial effluent connections to stormwater systems, and so on. Stormwater should ideally be treated at the source and this is the rationale behind permeable asphalt roads, swales and buffers. Whereas in the past the objective of urban drainage was to remove rainwater from settlements as quickly as possible, the philosophy has changed towards retention and drainage as slowly as possible. Where stormwater transport is inevitable, the aim is also to remove and contain pollutants where the flow originates, at source, through vegetated and sand filters. This project proposes that passive treatment systems would be able to remove (or trap) pathogens from urban effluent, together with other pollutants such as nutrients, hydrocarbons, dissolved metals and toxic substances. The objective of this research is removal of dissolved substances and pathogens from stormwater outlets, and is complementary to initiatives such as litter traps, or source control measures. Natural wetlands remove pollutants and improve surface water quality greatly while constructed wetlands have long been used as polishing processes downstream of municipal wastewater treatment. Three generations of constructed wetlands consist of the surface flow wetland, subsurface flow wetland, and vertically integrated wetland that shares characteristics with trickling filters and slow sand filtration. An important difference between the constructed wetlands as used downstream of wastewater treatment works and downstream of urban effluent discharges is the variability of flow: treated effluent runs at a steady flow rate with recurring daily peaks, while an urban effluent discharge would see highly variable flow

rates and composition, followed by periods of low or no flow. This study will include design of an experimental rhizofiltration system, where the wetland plant root zone provides oxygen and a biofilm habitat for treatment, where the filter material is selected to accommodate high flow rates, and which is hydraulically flexible to operate as different kinds of wetlands according to the above classification. The research work would be the performance evaluation of such a system under different conditions.

Cost: 2 400 000

Term: 2010 – 2012

Exploring knowledge on natural processes for novel approaches to constructed wetland design and performance for wastewater using biomimicry

Golder Associates

2096

This study will look to exploit knowledge on natural wetlands, their processes and biodiversity to better engineer/design constructed wetlands to meet the challenges of current and emerging pollutants and pathogens. The study should also look to explore the potential of using constructed wetlands to support sustainable livelihoods. The first phase of this project is innovation-focused and will explore, through the process of biomimicry, novel approaches that can be used to improve constructed wetland design and implementation. The potential exists for this process to deliver innovative solutions for wastewater (both

industrial, domestic) treatment, transformation and filtration.

Cost: R3 000 000

Terms: 2011 – 2016

Understanding the mechanistic interactions of engineered nanomaterials (ENMs) with biological treatment systems during wastewater treatment – a case of metal and metal oxide ENMs

CSIR (Pretoria)

2374

To protect human health and promote environmental integrity, research towards understanding ENM interactions with WWTP biological treatment systems is crucial. Such knowledge will be useful in developing treatment technologies suitable for ENM removal from wastewater systems. This study is a continuation of a previous WRC project titled 'Fate and behaviour of engineered nanomaterials (ENMs) in wastewater treatment systems' (K3/2122/3). Whilst the previous project mainly focused on the general fate and behaviour of ENMs in wastewater, this work seeks to generate data and knowledge that elucidates the nature of interactions between the ENMs and the biological treatment system as well as understanding plausible elimination mechanisms for ENMs in WWTPs. The results will constitute critical knowledge necessary in the development of wastewater treatment technologies to deal with contaminants with nanoscale dimensions, so as to protect South African ecosystems. This study will

investigate the metal and metal oxide ENMs behaviour in wastewater to evaluate their removal over long-term exposure to wastewater, dissolution behaviour, and bio-sorption behaviour on non-viable and viable aerobic biomass.

Cost: R1 200 000

Term: 2014 – 2015

A feasibility study to evaluate the potential of using WSD design principles to strengthen planning for water-sensitive cities of the future

City of Cape Town; University of the Western Cape

2412

Project aims:

- Conduct a scoping exercise to evaluate suitable sites for a feasibility assessment study. This exercise will also evaluate the vision, strategy, organisational structure (i.e. planning divisions), resources, budgets and implementation strength of the institutions that may be involved in adopting WSUD
- Engage and share the water-sensitive urban design concept, framework and guidelines with relevant stakeholders and ensure buy-in of stakeholders throughout the project cycle
- Provide a baseline assessment of the selected catchment/s with relevant implementation partner/s
- Set specific WSUD objectives for the selected catchment with realistic design and performance objectives – including a comparative analysis between conventional design and WSUD objectives



- Screen and evaluate the feasibility of the WSUD options within current best planning and management practices, including the selection of appropriate technology options to meet design, cost and performance objectives
- Where possible, develop suitable templates for the various activities and recommend development of new tools or guidelines where gaps in knowledge exist
- Present options to key stakeholders and evaluate the feasibility of the options and the barriers to implementation and document opportunities for future potential demonstration partnerships
- Link knowledge and partnerships to the WRC Community of Practice Programme

Cost: R2 000 000

Term: 2014 – 2017

Development and management of a Water Sensitive Design Community of Practice programme

City of Cape Town; University of the Western Cape

2413

Project aims:

- Scope potential and current water sensitive design (WSD) project opportunities
- Establish project priorities and their potential to be implemented as WSD research projects
- Develop and maintain 'Learning Alliances'
- Scope institutional challenges associated with implementing WSD in the planning and implementing environment

- Strengthen and broaden the WSD researcher base for South Africa
- Develop a WSD project database and website
- Facilitate and coordinate partnerships with relevant sector players to convert potential WSD projects to demonstration projects for consideration by the WRC
- Consolidate WSD project information from additional research projects

Cost: R2 500 000

Term: 2014 – 2019

Biomimicry wastewater treatment technology – monitoring & evaluation

Isidima Design & Development (Pty) Ltd

2479

The biomimicry approach is based on learning from nature and then emulating nature's forms, processes and systems to solve challenges and create truly sustainable design solutions. Biomimicry South Africa has partnered with John Todd Ecological Design, Informal South, Greenhouse and Maluti Waters to develop innovative ecological technologies (Ecomachines) for treatment of wastewater streams in informal settlements. To date, two rounds of design work addressing the issue of highly concentrated greywater flowing out of two informal settlements in the Western Cape region has been completed. However, the application of these systems in informal settlements as innovative prototypes for treating wastewater (and managing stormwater) requires careful monitoring of the different components of the

systems and how they evolve over time, as well as the water quality. To ensure successful implementation of Ecomachine design and also to inform further designs, a research programme for monitoring and evaluating these Ecomachines is required. In this regard, three design solutions based on an ecological treatment system will be implemented, monitored and evaluated. The monitoring and evaluation of floral and faunal responses and succession over time, as well as the impact on water quality will therefore be conducted.

Cost: R500 000

Term: 2015 – 2017

Programme 2:

Application of appropriate technologies and tools

Nutrient and energy recovery from sewage: demo-researching an integrated approach

University of Cape Town

2218

Humans produce a significant amount of sewage, containing large quantities of nutrients (phosphates, nitrates and micro-nutrients). For example, humans typically excrete 1.6 to 1.7 g phosphorus per day, most of which (approximately 60%) is found in urine. Considering that natural phosphorus reserves are on the decline and are expected to be depleted by 2033, the use of sewage waste has the potential to be a major source of new phosphorus. An alternative technology that utilises seeded electrochemical precipitation (SEP) has the

potential to increase the yield and process efficiency of struvite recovery. The use of SEP has been investigated for the removal of calcium carbonate by Hasson and co-workers. This technique has not yet been applied to struvite precipitation, thus providing the opportunity for a novel nutrient-recovery technique. The first aim will be to investigate current nutrient- and energy-recovery technologies based on a systems approach to technology sustainability assessment, which will focus specifically on situation analysis and technology review, in which the analysis of nutrient flows, expected nutrient supply limitations and emerging organic food production will be examined. The second aim will be achieved by investigating the use of seeded electrochemical precipitation as a means to produce struvite crystals of a similar or better quality and size when compared to conventional precipitation techniques.

Cost: R1 426 987

Term: 2013 – 2016

The Activated Sludge Bios – a real-time tool to evaluate activated sludge process performance

Durban University of Technology

2376

The activated sludge (AS) process is an internationally acclaimed method for wastewater treatment, due to its environmental friendliness and economic feasibility. This biologically driven process could only be realised through the advent of engineered systems, which are designed to exploit naturally occurring biological activities. In these



systems, notable interactions are apparent between functional microbial organisms, process configurations and overall operational control, all of which ultimately affect the absolute performance and efficiency of the AS process. For effective management and optimization of the activated sludge process, it is imperative to have a thorough understanding of the possible interactions between the functional microbial organisms and process operations. To date, very little research has been conducted on correlating the dynamics of all functional microbial populations with the works operational conditions and process configurations, worldwide. From previous observations, it was clearly noted that a gap exists in the promulgation of knowledge between various groups in the wastewater community, which subsequently negates a thorough, holistic evaluation of works process performances and thus consistencies. The invaluable information and data generated in the previous project could therefore be used as a basis to expand the current research and to create an easily accessible information source. This study will focus on evaluating a greater number of works including both domestic and industrial WWTW. The overall aim is therefore to develop an interactive web-based tool. This new tool is envisaged to incorporate the current troubleshooting guide and complement it with an interactive, online information hub that establishes a self-sustaining network between wastewater engineers, microbiologists, works operators and the wastewater community at large.

Cost: R1 600 000

Term: 2014 – 2015

Best practices in sustainable water and wastewater management: a road map to Green Drop and Blue Drop for small to medium sized municipalities in SA

Water Group Holdings (Pty) Ltd; Sarah Slabbert Associates

2420

Project aims:

- To research and report best practice sustainable water and wastewater management in small- to medium-sized municipalities and produce a fourth WIN-SA lesson series comprising the following two case studies:
 - » Case study 1: Wrapped up! - W₂RAP interventions that paid off
 - » Case study 2: Risk-based planning delivers safe drinking water – a Blue Drop case study
- To establish the level of implementation (and impact thereof) of Risk Assessment Plans in municipalities that have completed W₂RAP and WSPs

Cost: R500 000

Term: 2014 – 2015

National survey of filamentous bacterial populations in activated sludge: identification and correlation with process parameters, wastewater treatment plant configuration, and geographical location

Cape Peninsula University of Technology; Durban University of Technology; City of Cape Town; ERWAT

2471

Most municipalities in South Africa, including the City of Cape Town, treat AS reactors as 'black-boxes' and rely on chemical indicators of system health. Performance problems are thus usually addressed in a reactive rather than a proactive manner. Microscopic floc analysis and filament identification are simple, cost-effective procedures that can add value to the physicochemical tests currently performed at laboratories affiliated to WWTWs. Improvement in the performance of WWTPs will assist municipalities to achieve Green Drop status, in turn protecting the environment and minimizing human health risks associated with exposure to inadequately treated effluent. The filament populations in AS will be identified and correlated with WWTP location, and a large range of physicochemical parameters. These results will be used to validate an existing statistical model and will feed into the BIOS tool which is currently under development at DUT. This project will contribute by providing a tool to assist municipal engineers and process controllers to alleviate and/or prevent filamentous bulking and/or foaming in AS WWTPs.

Cost: R1 600 000

Term: 2015 – 2018

In-line rheometry for continuous and efficient polymer dosing control to optimise sludge dewatering

Cape Peninsula University of Technology; City of Cape Town

2472

Urbanization is putting enormous pressure on infrastructure including water treatment plants (WTP) and wastewater treatment plants (WWTP). Optimising existing plants is one way of prolonging the life span of such installations. Many WWTP plants have sludge dewatering installations where treated wastewater sludge is dewatered for final disposal using land applications. The objective is to produce a filter cake with the highest total solids content and to achieve this the plant needs to be controlled optimally. One of the most expensive inputs in these plants is the polymers used as flocculants. Polymer is typically dosed at a rate of about 4 kg poly per dry ton solids, and at a polymer cost of about R50/kg, the annual chemical cost for a large wastewater treatment plant can total millions of Rands. However, controlling the optimum dosing cannot currently be done in the process in real-time, although it has been shown that huge savings can be made by optimizing the dosing rates using rheology. In this regard, the Flow Process and Rheology Centre and their Swedish Partners at SIK, the Swedish Institute for Food and Biotechnology, Gothenburg, Sweden, have developed an Ultrasound Velocity Profiling (UVP) system which, together with a pressure drop (PD) measurement, can continuously measure the rheological properties of viscous fluids in-line and in real-time. Out of this partnership, the Flow-Viz technology has already been tested at a WWTP in 2012 and 2014, and results have indicated that it's possible to measure the viscous properties of sludges. If this technology were successfully applied in controlling polymer dosing it could have a significant cost saving and improve the efficiency of sludge dewatering. This could also be extended to other process control aspects of other WWTP and WTP processes.



Cost: R860 000
Term: 2015 – 2017

Endocrine disrupting compound removal by wastewater treatment plants

Tshwane University of Technology; University of Pretoria (Medical)

2474

Worldwide reuse of surface water for potable water production is increasing and a significant share of this is from wastewater effluent. Being a water-scarce country, treated wastewater effluents have been playing a decisive role in refilling the demand of water in South Africa and approximately 14% of the potential water source is treated wastewater effluent. In this regard, increasing attention has been focused on endocrine disrupting compounds (EDCs) as pollutants in municipal wastewater. Studies have shown that these compounds can have a negative impact on the environment, and that in many cases they are not efficiently removed in wastewater treatment plants. Moreover, their destruction and transport out into the environment depend on the design and operational characteristics of these treatment systems and on the properties of the chemicals themselves. It is also important to note that insufficient measurements made at various stages within the wastewater treatment plants prevent adequate analyses on how each unit process contributes to degradation. Identifying the performance of each wastewater treatment process in removing EDCs will therefore assist in optimizing the existing treatment technology by developing accurate relationships between operational parameters and removal

of these compounds. There is also a need to consider a mass balance approach that takes into account all forms of the compound in both liquid and solid phases. Little is known about the issues of potential concern in performing mass balances in the South Africa context. The project will mainly focus on three types of wastewater processes that include activated sludge processes, trickling filters and an oxidation pond system. A comparison study of these processes will reveal the most effective systems or/and the best performing stage in removing EDCs and how to optimise each stage, thereby addressing several key data gaps in the removal of EDCs in various WWTPs.

Cost: R550 000
Term: 2015 – 2017

Programme 3: Stormwater and sewerage systems

A functional description of urban effluent treatment in a rhizofiltration system

Stellenbosch University

2378

The design of the rhizofiltration system potentially offers a sustainable, energy-efficient solution to prevent pollution in South African rivers. Once proven to be successful at a pilot scale, the results may influence policy and decision makers on water boards and in local governments to suggest the construction of full-scale rhizofiltration systems at strategic locations. Also, the design is such that once proved to be successful at a

pilot scale, the construction and upkeep of full-scale rhizofiltration systems can be conducted by unschooled workers from informal settlements along river banks. These communities could therefore be empowered to reduce pollution in their rivers. It is envisaged that the project will ultimately lead to the development of a conceptual model that can be used to guide experimental work and eventually the design of full-scale rhizofiltration systems, as well as better understanding of microbial, physical and chemical interactions within a rhizofiltration system.

Cost: R749 200

Term: 2014 – 2015

Sanitation technology assessment and evaluation

Partners in Development (Pty) Ltd

2414

Project aims:

- Develop a sanitation technology assessment & evaluation tool
- Produce a collection of informative sanitation technology dossiers
- Produce a dialogue report to inform future sanitation policy
- Host knowledge dissemination workshops to present the assessment tool to key stakeholders

Cost: R1 315 600

Term: 2014 – 2015

Programme 4:

Wastewater sludge and faecal sludge management

Energy and resource recovery from wastewater sludge – a review of appropriate emerging and established technologies for the South African industry

TruSense Consulting Services; Stellenbosch University; ERWAT

2475

Sludge management forms a huge part of wastewater operations. Whereas in the past sludge was viewed as nuisance waste to be disposed of at significant cost, there is now a general consensus in the wastewater industry that sludge is a potential source of valuable resources and alternative green energy. Moreover, sludge management and the shortage of electricity are also both known challenges in South Africa. Sustainable management of sludge and recovery of energy and other resources from sludge fall within the Water–Energy–Food Nexus programme. While there has been growing interest in implementing sludge-to-energy technologies, municipalities have lacked comprehensive information to enable them to make informed long-term decisions on which technologies to adopt. The current study therefore compares established technologies by evaluating biogas production in relation to other innovative emerging technologies resulting in a product that can be used either as solid biofuel or as soil conditioner, thereby contributing to the South African industry through provision of sustainable development solutions, new products and services for economic development, and human capital



development. The project will therefore address the gaps in knowledge on sludge-to-energy technologies identified in previous studies and also provide valuable information on both established and innovative emerging technologies that South African municipalities can use to formulate long-term sludge management strategies.

Cost: R950 000

Term: 2015 – 2016

Characterizing municipal wastewater sludge for sustainable beneficial agricultural use

University of Pretoria; ERWAT

2477

Project aims:

- To investigate the effect of sludge drying time and drying thickness on sludge: (a) nitrogen content, (b) organic matter composition, and (c) fertilizer value
- To investigate the effect of liquid sludge application based on crop water requirement vs. crop nitrogen requirement on crop growth and environmental pollution
- To investigate the nitrogen fertilizer value of composted sludge, belt-pressed and lime-treated sludge, aerobically-digested sludge and sludge from the Ladepa process in order to parameterize the database model

Cost: R1 500 000

Term: 2015 – 2018

Programme 5:

Sanitation technology and innovations

Piloting and testing the pour flush latrine technology for its applicability in South Africa

Partners in Development

1887

Recent research studies concluded by the WRC have raised many concerns about the long-term sustainability of dry sanitation technologies. The studies have found that the technology has led to unintended consequences due to misuse by users, as well as the lack of understanding of the science of dry sanitation systems. A combination of these factors and the stringent design requirements are proving it difficult to access pits for pit emptying. This is further compounded by user behaviour which is resulting in the intrusion of solid waste, plastics and other undesirables into the pits, resulting in difficulties around pit emptying and the rapid filling of pits. This coupled with the fact that there is no easy mechanical or physical modus operandi for servicing full pits. All of these issues are raising many new challenges which jeopardise the sustainability and the target set by government for coverage of sanitation. Amongst the suite of technologies, pour-flush latrines, which are used widely as a basic sanitation norm in South East Asian countries, have the potential to resolve many of these issues. However, very little promotion and application has been done in South Africa. This research study aims to create an understanding of

the technical, social and environmental challenges associated with its application.

Cost: R1 000 000

Term: 2009 – 2011

Demonstration and scaled-up implementation of pour-flush sanitation in South Africa

Partners in Development

2203

While many South Africans aspire to full waterborne sanitation, this is not an achievable goal given the many demands on limited resources. The alternative has been limited to VIP's. However, these are not without their shortcomings including health and safety, environmental and operational issues. In 2009 the WRC commissioned a project to develop and test a prototype for pour-flush sanitation in South Africa. This was done successfully and 20 units have now been in operation for between 7 and 22 months. Funding was received from Irish Aid to demonstrate, on the strength of lessons learned, a large-scale pour-flush sanitation pilot and to share the experiences from this pilot with appropriate audiences. Thus, the objective of this study is to implement 275 pour-flush units in a rural community.

Cost: R1 475 175

Term: 2012 – 2013

Energy generation using low-head hydro technologies

University of Pretoria

2219

Energy is the lifeblood of worldwide economic and social development. When considering the current status of global energy shortages, the emphasis to reduce CO₂ emissions, development of alternative energy generation methods and growing energy consumption, it is clear that there is a need to change the way energy is created and used. Energy experts say South Africa has moderate hydroelectric potential, and that the establishment of small hydroelectric projects around the country could help provide a sustainable future energy supply. The US Department of Energy estimates that there are 6 000 to 8 000 potential sites in South Africa suitable for small hydro-utilisation below 100 megawatts, with the provinces of KwaZulu-Natal and the Eastern Cape offering the best prospects. This project therefore aims to:

- Review the feasibility of generating energy in low-head systems
- Develop guidelines to identify locations where low-head hydropower generation systems can be installed
- Develop an assessment model including a cost-benefit tool
- Demonstrate the technology by means of pilot-plant installations, testing different turbine technologies
- Provision of educational material to illustrate and describe the process.

Cost: R500 000

Term: 2013 – 2015



Eastern Cape school sanitation – pour flush pilot

Maluti GSM

2444

The objective of this project is to install pour-flush sanitation facilities in two schools within the Chris Hani District Municipal area of the Eastern Cape.

Cost: R372 100

Term: 2015

The development of wastewater anaerobic digestion for greater energy, water and nutrient recovery

University of Cape Town

2473

This project is focused on the development of an intensified AD process in which water treatment is

integrated through the nexus of energy-water-nutrient, producing biogas, purified water and high-value bioproducts from waste resources while recycling nutrients. Value can be created by intensifying the volumetric biogas production through decoupling COD depletion from methane production, allowing further downstream processes for clean water production as well as nutrient recovery (C, N, P) and bioproduct formation. The big-picture objective of this project is to utilise rural, industrial and municipal wastewaters which are currently treated with AD more fully, to integrate the process more successfully into actualising the energy-water-nutrients nexus. The project has potential to contribute towards the empowerment of communities, through managing waste to produce not only energy, as is the case currently, but also clean water and valuable bioproducts.

Cost: R1 454 486

Term: 2015 – 2018

THRUST 4:

SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1:

Emerging challenges and solutions for the 21st century

Evaluation of forward osmosis technology for the treatment of concentrated brines

University of KwaZulu-Natal (Durban); Sasol

2101

The aim of this project was to evaluate the feasibility of using FO for the concentration of high ionic strength wastewaters within Sasol, as a way of reducing costs associated with disposal of brines generated from desalination technologies. The use of FO was based on the technology's cost effectiveness. Unlike pressure and thermal driven processes, FO requires minimal external energy input, mainly for liquid circulation. Other

advantages include low fouling tendency, minimal pre-treatment of the feed, reduced cake layer formation which simplifies membrane cleaning, potentially high water recovery and low pressure operation which simplifies design and equipment used. The specific objectives of the study included:

- Evaluating the advantages, limitations and feasibility of using the forward osmosis technology to concentrate various high ionic strength wastewaters within Sasol
- Assessing the fouling characteristics of FO on various high ionic strength industrial streams which are characteristic of having high fouling and/or scaling potential

The study was divided into preliminary and synthetic studies. The study provided fundamental understanding of the application of FO for the concentration of high ionic strength wastewaters within Sasol as well as identifying the limitations associated with such applications, particularly the need for an ideal draw solution and appropriate membrane.

Cost: R354 000

Term: 2011 – 2014

Integrated bioremediation and beneficiation of bio-based waste streams

Rhodes University

2225

An integrated approach (ReBenFruWaste) for the remediation of fruit waste streams with high organic loadings with simultaneous beneficiation through the production of valuable products is proposed. The integrated approach will be evaluated on existing food waste streams, but could lay the foundation for the treatment and beneficiation of biorefinery waste streams when bioeconomies come to fruition. This project has four main aims:

- Analysis of existing food waste streams (fruit and olive mill waste streams) for sugar, lipid, phenolic and lignocellulosic content
- Bench-scale fermentations to evaluate (i) conversion of high sugar streams to ethanol (renewable fuel) and (ii) utilization of high streams with high lipid, phenolic and lignocellulosic content as feedstock for high-value enzyme production by *Aspergillus niger* strains
- Characterization of enzyme production and bench-scale demonstration of enzyme applications in different bioconversion processes, from lignocellulose conversion, treatment of resilient phenolic waste streams to the production of valuable fine chemicals, such as antioxidants
- Final cleaning of remaining waste streams through anaerobic digestion (can be combined with municipal waste treatment)

Cost: R750 000

Term: 2013 – 2016



Programme 2:

Integrated management

Revision of Natsurv 13: Water and Wastewater Management in the Textile Industry (Edition 2)

Cape Peninsula University of Technology; MKBros Development and Services

2489

In 1993, the NATSURV 13 document stated that the annual water intake of the textile industry in SA was $30 \times 10^6 \text{ m}^3$, with 70–80% of this intake later discharged as industrial effluents. In a country where water quality and availability issues are increasing, it is important to determine whether these figures are still accurate and determine how they have changed in the past two decades. Furthermore, wastewater management and wastewater treatment technologies have developed in strides in the past two decades, and it will be important to note if these management policies and technologies have been incorporated in the textile industry. The document will include a survey of the state and extent of the textile industry in South Africa, and will contain 'best practice' knowledge which will ultimately have a positive impact on the environment and a potential impact on the economy if implemented by the industry.

Cost: R900 000

Term: 2015 – 2017

Revision of Natsurv 10: Water and Wastewater Management in the Tanning and Leather Finishing Industry (Edition 2)

Chris Swartz Water Utilisation Engineers; Tannery Environmental Consultancy Services; International School of Tanning Technology; Cape Peninsula University of Technology

2490

Tanneries produce wastewater streams that contain high pollutant loadings that have a very negative impact on the environment if not treated effectively and satisfactorily before discharge to public streams or municipal sewer systems. Ineffective treatment or process operation may also lead to serious odour problems from these industries, while some of the chemicals used in the tanning processes may be toxic to humans and to the environment. High salt loadings in the effluent streams from curing of hide also present considerable problems for municipalities and the environment. Any improvement in water management and minimisation of pollutant loads in the waste streams will be invaluable in addressing water demand management and pollution control in our water-scarce country. The product of this project, the NATSURV 10 document, will not only be a valuable tool for the various tanneries and leather-finishing industries in the country, but will also sensitise the industry as to how they can contribute holistically towards reducing water usage and, especially, effluent generation, and to improving the quality of the effluent streams that are discharged from the tanneries.

Cost: R900 000

Term: 2015 – 2017

Revision of Natsurv 11: Water and Wastewater Management in the Sugar Industry (Edition 2)

Cape Peninsula University of Technology; MKBros Development and Services

2504

The sugar industry in South Africa is mostly concentrated in KwaZulu-Natal. In 1985, sugar production was approximately 2 million tonnes per year (NATSURV 11, 1990). In 2008/09, the SA sugar industry was producing 2.3 million tonnes of sugar per year, about 40% of which was exported. South Africa is one of the world's leading producers of cost-competitive, high-quality sugar and this industry makes a significant contribution to the national economy. One of the aims of this project is to determine the current scope and extent of the sugar industry in South Africa, how the landscape of the industry has changed since 1990 and what projected changes lie ahead. The document will include a survey of the state and extent of the sugar industry in South Africa, and will contain 'best practice' knowledge which will ultimately have a positive impact on the environment and a potential impact on the economy if implemented by the industry.

Cost: R900 000

Term: 2015 – 2017

Revision of Natsurv 9: Water and Wastewater Management in the Poultry Industry (Edition 2)

VitaOne8 (Pty) Ltd

2505

The Natsurv reports for different industries have been well used since they were developed by the sector in the 1980s. However, South Africa and its industrial sectors have either grown or in some cases shrunk considerably since the 1980s. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries, and therefore certain information contained in the national surveys needs to be updated. The project output will be a revised Natsurv 9 report which reviews and documents water and wastewater management processes in the poultry sector, with the goal of defining industrial best practices and identifying appropriate technologies for water and wastewater treatment.

Cost: R900 000

Term: 2015 – 2017

Programme 3:

Quantification, prediction and minimisation of water use and waste production

Using membrane distillation crystallization for the treatment of industrial wastewater

University of Cape Town

2223

The sustainable treatment of acid mine drainage and industrial wastewaters is necessary if sustainable growth and responsible management of water is to be achieved in South Africa. Membrane distillation crystallization offers a sustainable wastewater treatment process because it can utilise excess heat from processes, and produce



pure water as well as salt(s) products, thus converting waste material into something of value. Membrane distillation crystallization is also an attractive wastewater treatment technique because it requires low operating temperatures (40–60°C); the hydrostatic pressure encountered in the process is lower than in reverse osmosis and less expensive material such as plastics can be used in the process. Another major advantage of MDC to the application of AMD is that the process is able to operate in very acidic or basic streams and thus the AMD streams would not need to be pre-treated or neutralized beforehand. This project therefore aims to investigate the applicability of MDC for the treatment of industrial wastewater, with a specific focus on the treatment of mine wastewater. The project also aims to contribute to the field by investigating concentration polarisation and its effect on the process, while at the same time developing better crystallizer control strategies. Ultimately, this project could offer a more energy-efficient and sustainable industrial wastewater treatment process that reduces wastewater production.

Cost: R1 400 000

Term: 2013 – 2016

Revision of Natsurv 4: Water and Wastewater Management in the Dairy Industry (Edition 2)

University of KwaZulu-Natal (Pietermaritzburg)

2226

In the 1980s the Water Research Commission and Department of Water Affairs embarked on a series of

national surveys for 16 industries. The Natsurv reports of the different industries have been well used by the sector. However, South Africa and its industrial sectors have grown, or in some cases shrunk, considerably since the 1980s. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. Through the UN CEO mandate, water stewardship discussions, water allocation and equity dialogues, we are also seeing a growing awareness around water use, water security and waste production. Thus, this is considered an opportune time to review the water and wastewater management practices of the different industrial sectors. This project reviews 'Natsurv 4: Water and Wastewater Management in the Dairy Industry' and documents water and wastewater management within the dairy industry as part of the first stage of revisions of the Natsurv Series 1 to 16.

Cost: R700 000

Term: 2013–2015

Long-term forecasts of water usage for electricity generation: South Africa 2030

Quantitative Evidence Research cc

2383

Water and energy are key resources required for social and economic wellbeing and both are increasingly scarce. Extracting, delivering and disposing of water requires energy and extracting and refining fuels and producing electricity requires water. This water–energy nexus is becoming

increasingly important due to increasing energy demands and decreasing freshwater supplies. While it is estimated that power plants account for approximately half the global industrial water withdrawal, limited studies have investigated the water–energy nexus in South Africa. The aspect of water usage becomes critical when taking into account the state of water scarcity. The objective of this project is to fill this knowledge gap and identify current water requirements for electricity production currently, and, based on future electricity demand projections, to develop conditional forecasts for the demand on water supplies. This work will be important for water and energy policy development.

Cost: R306 000

Term: 2014 – 2015

Programme 5:

Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Micro-nutrient requirements for anaerobic digestion of concentrated industrial effluents: Development of a speciation/precipitation model to optimise micro-nutrient dose for methane production from industrial waste streams

University of KwaZulu-Natal (Howard College Campus)

2228

Anaerobic digestion of industrial effluents is used to convert organic material at concentrations that are too low for economic recovery to methane gas. Balanced anaerobic digestion requires inorganic micronutrients to proceed.

In many industries, including hydrocarbon and certain chemical industries, effluent streams may contain a number of the micronutrients required for balanced growth, but there may be several micro- (and macro-) nutrients that are not present in the stream. To date, research in the field has been predominantly experimental and empirical; there are no studies which provide guidelines for predicting the micronutrient requirements for a particular application beyond the general micronutrient-to-COD ratios. Therefore, this study will test the hypothesis that a model describing the partitioning of micronutrients between soluble, precipitate and potentially bound and adsorbed phases can be used to determine the amount of the micronutrient available for anaerobic digestion, and can therefore be used to predict the microbial response to different micronutrient dosing strategies.

Cost: R400 000

Term: 2013 – 2016

Phase 2: Recovery and beneficiation of nutrients and water from brewery effluent by means of unique combination of algal assimilation, constructed wetlands, hydroponics and aquaculture

University of Cape Town; Rhodes University

2284

Project aims:

- Develop a better understanding of (i) the changes that take place in HRAP algal community structure at different times of year and/or at different flow rates, and (ii) the underlying mechanisms responsible for



some of the results obtained in the HRAP during Project K5/2008, such as the mechanism/s responsible for majority of the ammonia and phosphate removal.

- Develop technology to convert brewery effluent grown algal biomass into fish biomass without mechanically harvesting the algae and allowing filter-feeding fish to bioconvert algal biomass into fish biomass

Cost: R850 000

Term: 2013 – 2016

The use of modified multi-walled carbon nanotubes for the selective extraction of Cr(VI) and mercury from industrial effluents

University of Johannesburg

2387

Hexavalent chromium) and mercury (both inorganic and organic forms) are two priority pollutants, and although treatment methods such as ion exchange, chemical precipitation and reverse osmosis have been used, adsorption has been identified as a key process in metal ion removal due to its efficiency. Adsorption by activated carbons has been popular for both pollutants. However, activated carbon suffers from disadvantages, such as lack of selectivity for a specific pollutant. Carbon nanotubes are a new form of nanomaterials which have been gaining increasing recognition for their applications in environmental remediation, due to their superior adsorption capabilities to conventional adsorbents like activated carbon. This project therefore aims to investigate the use of carbon nanotubes as selective sorbents for the two

metals of interest. The emphasis is on multi-walled carbon nanotubes, since these are cheaper, easier to synthesise and more readily available than single-walled carbon nanotubes.

Cost: R1 000 000

Term: 2014 – 2017

Anaerobic and photocatalytic treatment of textile and distillery wastewater in integrated fluidized bed reactors

Vaal University of Technology

2388

The treatment of many industrial wastes requires the application of robust and costly techniques, which is a major deterrent. It is for this reason that biological methods have proved to be very attractive to both industries and local authorities. However, these systems, used as stand-alone techniques, are not efficient in treating some high-strength industrial wastewater. Generally, biological wastewater treatment, especially anaerobic digestion (AD), has been the technique of choice for many years due to its simplicity and low cost, but AD is challenged by the presence of xenobiotic and recalcitrant compounds. Process efficiency and robustness may be improved by integration with another process, such as ion exchange, membrane processes, or advanced oxidation processes. This study will investigate the development of a combined bioreactor/photoreactor and its applicability to common South African industrial wastewaters.

Cost: R1 200 000

Term: 2014 – 2017

Shale water treatment

University of the Western Cape (SAIAMC); Wageningen University

2502

While greatly increasing nations' wealth and creating thousands of new jobs, exploration of shale and unconventional natural gas production methods can have potentially serious negative environmental effects. One of the most serious public sector concerns in this regard is associated with groundwater contamination. It is of paramount importance for any commercial operator to have at hand effective water treatment technologies to alleviate the plethora of risks associated with the potentially disastrous contamination of the environment. Due to the unique geological situation in South Africa, locally produced shale water needs a tailored purification approach with the development of technology for selective removal of specific species. As the knowledge to be created over the course of this project is focused on South African shale water, it is expected to be of great value to South Africa in particular. The project aim is to develop cost-effective water treatment systems tailored for the shale water market. New electrodes, absorbent integrated electrode manufacturing technology (with absorbents based on local minerals), and hybrid purification systems will be developed and demonstrated using a locally developed renewable energy system.

Cost: R2 421 875

Term: 2015 – 2019

Fate and behaviour of nano-TiO₂ nanoparticles in simulated textile wastewater

University of Johannesburg; Cape Peninsula University of Technology; University of Johannesburg

2503

The use of engineered nanomaterials (ENMs) to treat dyeing effluents creates secondary pollution in the form of metal oxide nanoparticles. Following increasing use and applications of nanotechnology, wastewater treatment plants (WWTPs) have been identified as a major point source for ENMs entering aquatic systems. Little is known about the removal efficiency and adverse effects of ENMs in WWTPs. For instance, ENMs in WWTPs may adversely impact on microbial consortia useful for the treatment process. Studies have been initiated only recently in determining potential removal mechanisms for ENMs during wastewater treatment as well as their fate and behaviour in terms of uptake and bioaccumulation. This project will investigate the fate and behaviour of doped and undoped TiO₂ and bimetallic oxide nanoparticles in a model wastewater treatment process. The study will establish the extent to which metallic- and metal-oxide nanoparticles are either removed or released during wastewater treatment, or persist in the treated water.

Cost: R900 000

Term: 2015 – 2017



THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1:

Water use and waste production

An industrial ecology approach to sulphide-containing mineral wastes to minimise ARD formation: characterising potential for ARD, design for disposal and extraction of products with value

University of Cape Town

2231

Project aims:

- Develop a method for characterizing the long-term ARD generation potential that takes into account the likely impact of microbial colonization and the relative time frame of acidification and neutralization, building on the proposed concept of the biokinetic test (Hesketh et al., 2010)
- Provide an expanded techno-economic assessment and holistic environmental assessment of the sulphide separation step for removal of risk of ARD formation
- Develop appropriate uses for the benign tailings generated in line with the principles of industrial ecology based on maximizing resource productivity and minimizing waste burden
- Develop appropriate uses for the sulphide-rich tailings resulting from the separations in line with the principles of industrial ecology based on maximizing resource productivity and minimizing waste burden

Cost: R2 565 000

Term: 2013 – 2017

The BioSURE Process: a sustainable, long term treatment option for acid mine drainage treatment

VitaOne8 (Pty) Ltd

2232

The BioSURE Process was identified as one of few treatment options suitable for the treatment of AMD in the Witwatersrand and elsewhere. However, it has been rejected by Aurecon, in their feasibility study for the Witwatersrand, as a viable option for the long-term treatment of AMD, the reason cited being a lack of full or demonstration-scale operating data. The full-scale operation undertaken by the East Rand Water Care Company (ERWAT) has in fact demonstrated that the BioSURE Process can be used as a cost-effective treatment technology for AMD. The process is attractive because it makes use of primary sewage sludge or other sources of organic wastes as substrate and produces a good quality effluent. Since it converts permanent hardness into temporary hardness, conventional cold-lime softening processes can be used to desalinate the water while valuable by-products may be recovered. The effluent quality after desalination is suitable for consumption in various industries as a substitute for high-quality potable water. ERWAT, in its role as a service provider, is very well positioned with its access to sources of primary sewage sludge and biodegradable organic waste. As an operating company and with the past experience of operating a 10 ML/day plant, it can play a significant role in the treatment of AMD. A survey

of the industries indicated that there are reliable and consistent sources of waste, other than primary sewage sludge, from various industries to treat approximately 20-30 ML/day of AMD in the Central and Eastern Basins. This waste is currently being disposed of in landfill sites at high cost. Considering the quantity of primary sewage sludge generated by ERWAT and Johannesburg Water's wastewater treatment plants that can practically be used, a significant volume of AMD can be treated in the Witwatersrand. Co-treatment with industrial waste and recovering costs for treatment of industrial waste will reduce the overall treatment cost of AMD. It is therefore important that more aspects should be considered than only the need to treat AMD. These aspects include the requirements to treat and dispose of sewage sludge and the urgent need to provide additional capacity to process biodegradable organic solids. This project is required in order to improve the BioSURE Process and to properly document its operating philosophy and limits to applicability, in order to make it truly available for implementation. It is planned to:

- Compare the performance of the biological sulphate-reducing reactors using primary sewage sludge and carbohydrates such as silage and combinations thereof
- Test the performance of the process using a feed of high acidity, low pH AMD
- Investigate the removal of hydrogen sulphide using a process to regenerate iron hydroxide with a biological iron-oxidising process integrated with the recovery of valuable magnesium sulphate using a eutectic freeze unit
- Investigate the integration of the effluent treatment process with the so-called SANI process for COD and nitrogen removal

Cost: R1 557 600

Term: 2013 – 2015

Prevention of acid rock drainage (ARD) formation from fine coal and tailings fractions by sulphide removal: the role of bioflotation reagents

University of Cape Town

2389

UCT has developed an approach to attaining benign tailings and waste materials for disposal from sulphur-containing fine coal fractions, base metal and gold tailings, either at the point of generation or through the re-processing of waste deposits. The separation is based on flotation with the potential for improved resource productivity in addition to acid rock drainage (ARD) prevention. There is a growing body of literature on the use of biological agents as flotation reagents. In this project, we will investigate the use of bioflotation for both the recovery of coal from coal fines and the recovery of pyrite from both coal fines and base metal tailings fractions. Our aim is that, should successful flotation processes be defined, the flotation reagents would be such that they could be manufactured cost effectively on site using waste organic resources in the vicinity of the site of application, thereby removing the transport requirements. Secondly, such reagents would need to meet the specifications of being non-toxic and completely biodegradable.

Cost: R1 247 513

Term: 2014 – 2018



Programme 3:

Minimising waste production

Treatment of mine water using a combination of coal fly ash and flocculants in a jetloop reactor system

University of the Western Cape

2129

The generation of contaminated high-sulphate mine-water and waste coal fly ash are undesired by-products in coal mining and coal-fired power stations, respectively. Mine-water is contaminated by contact with oxygen and pyrite-bearing rock, or leaches from mine tailings due to infiltrating rain. Mine-water produced in coal mines could be acidic, neutral or alkaline depending on the geology of the mines. Acidic mine-water, often termed acid mine drainage (AMD) is produced when rock that contains more acid-producing minerals than acid-neutralizing minerals was disturbed during mining. Prior work has been done on the fly ash neutralization process and stability of solid residues formed during neutralization, as is recorded under the 'general information' section. This study will optimize the jetloop reactor system which will make this system using fly ash for remediation viable in an industrial environment, and thus a serious contender for low cost mine-water treatment and recovery.

Cost: R1 033 000

Term: 2012 – 2015

Continuous eutectic freeze crystallization

University of Cape Town

2229

While treating coal mining-impacted waters using reverse osmosis, facilities such as the Emalahleni Water Reclamation Plant and the Optimum Water Reclamation Plant produce large volumes of hypersaline brines. These brines are disposed of in evaporation ponds, and thus are lost to the usable water pool. With increasing use of desalination, and hence brine production, the loss of water is predicted to increase exponentially. The total combined brine production rates for the coal and gold mining industries in South Africa are projected to be $\pm 17\,000\text{ m}^3/\text{day}$ in the next 20 years from current values of $\pm 3\,000\text{ m}^3/\text{day}$. Conventional treatment methods, such as concentration in evaporation ponds, have many disadvantages including extensive land use and low productivity. In addition, evaporation ponds recover neither the water nor the salt. Eutectic freeze crystallisation (EFC) is able to reduce the volume of brines by as much as 97% and concurrently produce pure salts as well as potable water. For example, pure calcium sulphate, pure sodium sulphate and potable water, in the form of ice, can be produced. Eutectic freeze crystallisation works on the principle that when brine is cooled to the eutectic temperature, both ice and salt crystallise out of solution. The ice, being less dense than water, will float, and the salt, because it is denser than water, will sink, thus effecting gravity separation. There is a major misconception that any freezing process is expensive but, thermodynamically, it is cheaper to freeze one kilogram of water (333 kJ) than to evaporate one

(2 300 kJ). Energy savings of 85% have been reported when comparing EFC to evaporative crystallisation. An extensive experimental programme focussing on the use of EFC has been undertaken over the past 6 years and proven the concept of EFC as a feasible treatment for multi-component hypersaline brines. Firstly, it was shown that thermodynamic modelling can accurately predict the identities of the recovered salts, as well as their recovery temperatures. Secondly, it was shown that EFC can be used for the treatment of hypersaline brines and inorganic effluents produced by major South African industries. Thirdly, it was shown that EFC can be used to recover multiple salts from multicomponent brines. Lastly, it was shown that EFC can produce almost pure salts and ice. However, all of the work so far has been done in batch mode, an essential mode for testing proof of concept and initial feasibility. Although the batch mode has provided crucial information, it has not been sufficient to showcase the potential of the technology. The next challenge is to develop EFC to the point that it can be used in continuous mode. In this project, important knowledge about operational considerations for continuous EFC, including residence time, degree of undercooling, crystalliser solids content and operating limits, will be generated. This knowledge is crucial for making the transition between batch and continuous, as well as to be able to design an EFC plant on both a pilot and industrial scale. This is the essential focus of this project.

Cost: R2 276 600

Term: 2013 – 2018

Improving evaporation rates of mining wastewaters

University of the Western Cape

2390

Coal-mining activities generate wastewater, and the minimization of wastewater, through its reuse, or safe re-entry into the hydrological cycle, is a critical part of water management and integral in tackling water scarcity issues. The resulting wastewater brines are complex liquid mixtures of different salts with a composition that varies depending on the water process system used to produce the final saline effluent. As a result of the large quantities produced and due to its chemical composition, there is a need to properly and safely dispose of the brine solution. Evaporation ponds evolved years ago, and they are still considered the most effective brine management option due to several advantages which include easy construction, low maintenance and little operator attention. Predicting the evaporation rate of the pond is critical in effective management of the brine disposal holding area. This is a concern with increasing salinity due to the large amount of dissolved salts in the ponds, as this results in a decreased rate of evaporation. The consequence of this is the need to build additional ponds, which requires large areas of land. The objective of this study, therefore, is to investigate methods to improve the evaporation rate of brine in ponds using chemical and halophilic biological colouring agents to increase the absorption of insolation.

Cost: R1 795 960

Term: 2014 – 2018



The synthesis of highly selective immobilized ligands for extraction of toxic metal ions from waste water

University of the Western Cape

2391

It was reported by Madzivire et al. (2012) that the concentration of radionuclides in Rand Uranium mine-water was above the target water quality range (TWQR) for potable water set by the Department of Water and Sanitation by a factor of 12. Generally, discharges of radioactive elements such as uranium, thorium and strontium to surface and groundwater originate from anthropogenic sources. Although there are a number of conventional extraction methods that remove radionuclides from water using ligands, in most cases the ligands are destroyed and the metal ions cannot be recovered for re-use. This means new ligands must be produced for each treatment cycle, and the spent ligands carrying the radioactive ions must be disposed of responsibly. The purpose of this project is to develop a method which will enable the recovery of both the ligands and the metal ions so that both can be reused.

Cost: R765 362

Term: 2014 – 2018

An integrated bioprocess for AMD remediation and renewable energy generation

University of Cape Town

2392

Acid rock drainage (ARD) remains one of the biggest environmental threats facing South Africa and is already

having a negative impact on the quality of several important water resources. There are two main sources of ARD in South Africa: firstly, the rebound of groundwater through underground workings, which typically has a high volume, low pH, high metal and sulphate load and tends to be restricted to a single discharge point, and is suited to active treatment. The second source of ARD is diffuse, such as spoil heaps, waste rock dumps and open pits, whose waters vary substantially in volume and composition, and are more amenable to passive or semi-passive treatment. This research will result in a design for an integrated, sustainable biological process with the ability to treat low to medium volume ARD streams. The potential for energy recovery, both as biogas and electricity, will be assessed.

Cost: R2 372 862

Term: 2014 – 2019

Application of next generation sequencing and metagenomic analysis to characterise mixed microbial communities involved in sulphur metabolism

University of Cape Town

2393

Acid rock drainage (ARD) remains one of the biggest environmental threats facing South Africa. Biological desalination of ARD has been implemented to some extent, but due to a lack of a detailed understanding of the micro-organisms responsible for the process (mainly due to inadequate methods for identifying and quantifying the microbial ecology within the process unit), it has been applied as a 'grey box'. The advent of culture-independent molecular biology techniques has

facilitated a more complete assessment of the microbial ecology, and the most recent advances in metagenomics, combined with either transcriptomics or proteomics have opened the way for deep, genomically-resolved analyses of the metabolic potential of microbial consortia. Genome resolution enables a far more complete view of metabolic capacity and functional roles, as well as evolutionary processes, than is possible using datasets with minimal or no assembly and provides the foundation for community proteomic and transcriptomic measurements. Genome reconstruction-based metagenomics analyses will be applied here to biological ARD desalination. Important information on the metabolic potential of component species and the interactions between community members will be derived.

Cost: R1 754 440

Term: 2014 – 2018

Biogeochemical cycle of mercury in natural and manmade wetland ecosystems affected by gold mining and industrial activities in the Witwatersrand Basin – modelling and remediation

University of the Witwatersrand

2394

Wetlands are essential habitats in the environment since they fulfil a variety of ecological functions. One of the major characteristics of wetlands is their ability to act as chemical sinks. Due to this, they tend to accumulate pollutants that are introduced into the environment such as lead, copper, zinc, chromium and mercury. The nature, the level and the impact of mercury in the

environment has not been extensively studied in South Africa, particularly in areas that have been significantly affected by mining activities. The reports are mainly from coal combustion and chlor-alkali plants. No seasonal changes and bioaccessibility have been reported. There is therefore a need to carry out a detailed assessment and evaluation of the impact of mercury in Gauteng, an area very densely populated and with intensive water use.

Cost: R950 000

Term: 2014 – 2018

Programme 4: Mining in the 21st century

Paques pilot and demonstration plant

Project Assignments SA (Pty) Ltd; Paques bv
2480

This project forms part of a programme focused on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention and treatment strategies. Waste minimisation at the national, regional, (catchment), complex or single site scale is considered. The DWS investigation into the feasibility of various options for the long-term management of mine water in the Witwatersrand has identified the Paques process as a treatment method which has potential for mitigation



of the mine water situation in this region. However, the process has not been trialled at demonstration scale in South Africa. This project will design, construct and operate a public Paques process pilot and demonstration plant, at a site in the Witwatersrand region.

Cost: R2 800 000

Term: 2015 – 2018

Electro-coagulation pilot and demonstration plant

Tecoveer

2481

This project forms part of a programme focused on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention and treatment strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. The DWS investigation into the feasibility of various options for the long-term management of mine water in the Witwatersrand has identified the electro-coagulation process as a treatment method which has potential for mitigation of the mine water situation in this region. However, the process has not been trialled at demonstration scale in South Africa. This project will design, construct and operate a public electro-coagulation process pilot and demonstration plant, at a site in the Witwatersrand region.

Cost: R2 800 000

Term: 2015 – 2018

Ettringite process pilot and demonstration plant

Miwatek

2482

This project forms part of a programme focused on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life-cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention and treatment strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. The DWS investigation into the feasibility of various options for the long-term management of mine water on the Witwatersrand has identified the ettringite process as a treatment method which has potential for mitigation of the mine water situation in this region. However, the process has not been trialled at demonstration scale in South Africa. This project will design, construct and operate a public Ettringite process pilot and demonstration plant, at a site in the Witwatersrand region.

Cost: R2 800 000

Term: 2015

Alternative reverse osmosis pilot and demonstration plant

Miwatek

2483

This project forms part of a programme focused on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life-cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention and treatment strategies. Waste minimisation at the national, regional,

(catchment), complex or single-site scale is considered. The DWS investigation into the feasibility of various options for the long-term management of mine water on the Witwatersrand has identified the alternative reverse osmosis process as a treatment method which has potential for mitigation of the mine water situation in this region. However, the process has not been trialled at demonstration scale in South Africa. This project will design, construct and operate a public alternative reverse osmosis process pilot and demonstration plant, at a site in the Witwatersrand region.

Cost: R2 800 000

Term: 2015 – 2016

THRUST 6: WATERSMART FUND

An investigation of the treatment efficacy of permeable pavements with a view to harvesting stormwater for use in South Africa

City of Cape Town

2409

Project aims:

- Undertake an investigation of the treatment efficacy of permeable pavements in South Africa with a view to harvesting stormwater for use
- Assess the design and maintenance of existing permeable pavements and make recommendations

for improvements where necessary

- Fine-tune the assessment methodology for South African conditions to test the treatment efficacy of other stormwater management technologies / sustainable drainage system (SuDS) technologies in the future
- Develop a database for collecting performance data for different SuDS technologies operating under varying conditions

Cost: R500 000

Term: 2014–2016



NEW PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1:

Cost-recovery in water services

Proof-of-concept of the application of Strategic Adaptive Management in the water services sector prior to full-scale demonstration

Amanzi Obom Consulting cc; Department of Water and Sanitation (Western Cape); SALGA; AWARD; Stellenbosch University (Civil Engineering); IMESA; Department of Cooperative Governance and Traditional Affairs

1123

Project aims:

- Review literature (especially as it relates to case studies) and clarify and map the concepts and processes of Strategic Adaptive Management (SAM) and Adaptive Management (AM)
- Prove or disprove that the SAM concept is applicable to water services by modifying SAM to enable a truncated process and co-create a strategy related to a national government programme through a series of workshops

Cost: R300 000

Term: 2016 – 2017

Programme 2:

Institutional and management issues – Water services

Assisting municipalities to determine the most appropriate indicator for funding allocations toward operations and maintenance

PDG

1121

Project aims:

- Consolidation and review of existing literature for determining appropriate allocations towards operations and maintenance
- Provide clarity on definitions and the manner in which indicators are calculated and applied
- Recommend appropriate indicators to be used and the context in which this can be applied

Cost: R237 318

Term: 2016 – 2017

Piloting and refining a school sanitation management model

Partners in Development (Pty) Ltd; KZN Department of Education (Infrastructure); University of KwaZulu-Natal (Pietermaritzburg)

2575

Project aims:

- To observe the impact of a range of management interventions as opposed to infrastructure interventions -- on the degree to which learners enjoy conditions that support their health, safety and dignity in their experience of school sanitation
- To test the use of tools that have been developed to assist with the management of school sanitation and evaluate and refine their design with feedback from implementers
- To explore the beliefs and attitudes of principals with regard to service and status, responsibility, authority and agency and the impact of these on the way they address learners' needs (for health, safety and dignity) with regard to school sanitation; to engage principals with regard to their role; and to evaluate the impact of the exploration and engagement on principals' beliefs and attitudes
- To explore the impact of sanitation management on learners' experience of dignity and respect
- To empower participating principals and SGBs with the attitudes, knowledge and tools to be able to manage school sanitation successfully and model their success to others in their district
- To explore opportunities within the structures and systems of the KZN Department of Education (DoE) to provide greater support to schools with regard to sanitation, particularly in terms of financial, monitoring and accountability structures and systems, as a model which could be replicated in other provinces
- To provide South African DoEs and rural schools with a tested sanitation management programme which protects the health, safety and dignity of learners

- To influence policy development in the DBE and provincial DoEs to more strongly support effective management of school sanitation

Cost: R1 000 000

Term: 2016 – 2018

Assessing the affordability of water to the residential sector based on consumption

PDG; University of Cape Town

2584

Project aims:

- Provide an assessment of the current status of residential water affordability in South Africa
- Estimate the economic value which households assign to water and the degree to which there is variability in such value, based on various household income bands and socio-demographic characteristics
- Investigate the means by which water affordability can be measured in terms of consumption and whether there are opportunities for the improved measurement thereof through the use of municipal billing data and census information
- Provide recommendations for the means by which household water affordability can be improved to enhance the livelihoods of South African households

Cost: R861 000

Term: 2016 – 2018



A review, alignment and reform of the national and international water supply and sanitation monitoring and reporting requirements: Alignment of the water and sanitation functions to respond to new national (NDP; NWR52) and international (SDG) obligations

Sustento Development Services cc

2588

Project aims:

- To review South Africa's future national and international water services monitoring and reporting obligations
- To develop a Monitoring and Reporting Framework to address South Africa's future national and international water services monitoring and reporting obligations
- To determine and address the gaps in current water services monitoring and reporting frameworks to ensure that future WSS monitoring and reporting requirements can be met
- To develop tools and a guideline to facilitate the implementation of the WSS Monitoring and Reporting Framework
- To test the WSS Monitoring and Reporting Framework tools and guideline
- To develop a training and capacity building guideline to facilitate implementation of the WSS Monitoring and Reporting Framework

Cost: R893 900

Term: 2016 – 2018

Mitigating the impact of electricity disruption on water supply – case study of the City of Tshwane

Umfula Wempilo Consulting; University of Pretoria; City of Tshwane

2591

Project aims:

- Evaluate the risk to water supply posed by short-term and long-term electricity supply disruption
- Determine suitable institution arrangements to mitigate impacts
- Determine appropriate infrastructure design changes
- Estimate the costs of such measures and prioritise the steps to be followed
- Develop appropriate institutional and design guidelines

Cost: R800 000

Term: 2016 – 2018

Programme 3:

Innovative management arrangements – Rural water supply

The Internet of things: opportunities for the WASH sector

CSIR

2779

Project aims:

- Study Internet of things (IoT) in relation to WASH services
- Report on IoT opportunities related to WASH services

- Report on potential challenges, successes and failures related to IoT enabled WASH services
- Present a future view of IoT in a WASH context

Cost: R300 000

Term: 2017 – 2018

Programme 5:

Water services education and awareness

Impact of behavioural messaging on water consumption and technology uptake: evidence from a randomized experiment in South Africa

University of Cape Town; University of Sussex

2596

Project aims:

- Reach a formal agreement with City of Cape Town which ensures full financial buy-in and support going forward
- Implement measures to ensure that knowledge and skills transfer occur that will allow for the integration of behavioural interventions within the ambit of the City's DSM tools/strategies
- Examine how different behavioural messages influence residential water usage across all income groups over the long term
- Compare the impact of a tariff increase on water consumption to the impact of behavioural messaging
- Consider the impact on consumption of using behavioural messaging in conjunction with a tariff increase (relative to relying solely on a tariff increase)

Cost: R2 000 000

Term: 2016 – 2019

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1:

Drinking water treatment technology

A comparative life cycle assessment (LCA) for the provision of potable water from alternative sources (seawater, wastewater and mining water) in South Africa

University of KwaZulu-Natal (Howard College); Veolia

Water; Umgeni Water; eThekweni Municipality

1122

Project aims:

- To generate environmental information by investigating each of the water treatment technologies (desalination, recycling of wastewater and reclamation of mine water)
- To improve the overall environmental performance of these processes
- To guide designers and owners of these potential life-cycle environmental consequences of the selected technologies



- To develop capacity in undertaking life-cycle assessments

Cost: R200 000

Term: 2016 – 2018

Modelling advanced oxidation of persistent chlorohalogenated pollutants in aqueous systems

University of Pretoria (Chemical Engineering); Sedibeng Water

1125

Project aims:

- To conduct batch reactor system design and optimisation of operational parameter using systematic preliminary studies
- To perform batch studies and kinetic determinations of the photocatalytic sequence and system performance on the oxidation of polychlorinated substituted phenols in aqueous systems
- To determine reaction mechanism, evaluate and develop a sufficient mathematical model for the photocatalytic transformations of each chlorophenol

Cost: R200 000

Term: 2016 – 2017

An assessment of fungal occurrence in treated drinking water in Johannesburg West and implications to public health

UNISA (Florida); ARC Animal Production Institute

2568

Project aims:

- To identify sampling sites along the treated drinking water distribution network in Johannesburg West. Sites to include taps (point-of-use), pressure control sites along the distribution network, and inlet and outlet points at drinking water treatment plants
- To collect treated drinking water samples and determine the densities of fungi and total and faecal coliforms
- To use molecular methods to characterise the fungi isolates to species level and determine the presence of mycotoxigenic fungi
- To analyse water samples for traces of different types of mycotoxins
- To statistically determine any correlations between the presence of coliforms and fungi in treated drinking water and the potential health impacts
- Make output-dependent recommendations about monitoring and the potential health impacts of fungi in drinking water distributions

Cost: R600 000

Term: 2016 – 2019

Guidance on drinking water treatment systems performance assessment and optimisation

Water Group Holdings (Pty) Ltd; CSV Water Consulting Engineers

2578

Project aims:

- To provide the best practices and processes for the assessment of drinking water treatment systems in South Africa

- To align assessment methodology and practice with the Blue Drop regulatory approach

Cost: R1 000 000

Term: 2016 – 2018

Framing desalination within the water–energy–climate nexus

EScience Associates (Pty) Ltd; University of Cape Town
2778

Project aims:

- Review and report of legal frameworks within which the planning and implementation of seawater desalination and associated environmental impacts are managed
- Water–energy–climate change nexus in the context of desalination, with emphasis on the potential role of desalination within a broader climate change adaptation strategy, considering both periods of drought and flood episodes
- Opportunities for energy generation, when the assurance of water supply in the nexus is raised through the introduction of seawater desalination
- Comparisons of the energy requirements for different desalination technologies, and emerging strategies for achieving:
 - » Energy efficiency through the use of energy reduction/recovery technologies and emerging energy efficient desalination technologies
 - » Sustainability through the use of renewable energy technologies

- Formulation of a research framework for desalination in South Africa including a stakeholder engagement process
- Formulation of policy recommendations for achieving water–energy–climate change security in South Africa

Cost: R300 000

Term: 2017 – 2018

Programme 2:

Water treatment for rural communities

Development of resource guidelines on greywater use and management

University of Cape Town; Stellenbosch University
2592

Project aims:

- Compile a report on the legislative context of greywater use and management in South Africa, including:
 - » Definition of terms and concepts
 - » Role of greywater management in water supply and food security
 - » Applicable regulations/ordinances/guidelines on greywater use and management
 - » Existing greywater use and management systems
 - » Recommendations for sustainable greywater use and management
- Develop guidelines for greywater use and management, taking into consideration the following aspects:



- » Greywater quantity/quality and fitness for use/application
- » Managing risks and uncertainty in greywater use/reuse
- » Use of greywater to supplement irrigation activities
- » Greywater management options, including treatment, disposal and reuse
- » Protocols for testing and validating treatment technologies
- » Guidance for household use and municipal greywater programme implementation in both seweraged and non-sewered settlements

Cost: R263 000
Term: 2016 – 2017

Development of resource guidelines for rainwater harvesting

CSIR
2593

The project aim is to develop a guideline document for establishing a municipal rainwater harvesting programme in both rural and urban settings, including:

- Specific codes or regulations for rainwater harvesting
- Rainwater harvesting infrastructure financing and related financial incentives/programmes
- To investigate the factors that must be considered when planning for rainwater harvesting, including institutional, technical, financial, social aspects, climatic conditions, etc., and develop recommendations based on each
- To develop user resource material on rainwater

- harvesting, covering system design and installation, system components, maintenance, allowable uses, owner responsibilities, and permitting requirements
- For each water use category, identify the water quality requirements; necessary on-site treatment options and likely perceived public health concerns

Cost: R344 000
Term: 2016 – 2017

Programme 3: Drinking water quality

Antibiotic resistant bacteria and genes in raw and drinking water: Implications for water production and water quality monitoring

North-West University (Potchefstroom); Rand Water
2585

Project aims:

- To determine the physico-chemical and general microbiological parameters of the different water sources at the time of collecting water for the ARB resistance tests, qPCR and environmental metagenomic analysis
- To isolate and to determine the antibiotic resistance profiles of isolated bacteria for comparison to the next generation molecular evaluation methodologies
- To perform qPCR and environmental metagenomic analysis of DNA isolated directly from water and evaluate the analysis processes

- To evaluate the next generation molecular method data and determine the implications thereof
- Use the data for determining whether mitigation strategies are required and if this is positive then evaluate the options that are available

Cost: R1 526 000

Term: 2016 – 2019

A scoping study on microplastics in water environments

North-West University (Potchefstroom)

2610

Project aims:

- As part of the literature survey, to scan the literature on existing definitions of microplastics and particles. These definitions will be listed and discussed as to differences and concurrences.
- To conduct a comprehensive literature survey, including grey literature such as reports, on microplastics and microparticles in the aquatic environment. Much has already been done on marine microplastics and particles, and this will be translated into potential issues in the freshwater, estuarine, and coastal environment and water cycles of South Africa. Attention will also be given to drinking water, potential impacts on human health and the environment.

- To compile an annotated compendium of relevant sampling and analytical methods (water, sediment, and biological materials), with specific attention as to the situation and conditions in South Africa.
- To sample and analyse microplastics and microparticles in a variety of sediments and freshwaters, including drinking and groundwater.
- To construct a synthesis of the above, translated to the situation in South African fresh, estuarine and coastal waters and water cycles, including potential threats to human health and biota. Priorities will be identified, as well as possible and potential mitigating actions.
- To compile a list of research entities working on microplastics in South Africa.
- To develop proposals as to the standardisation of methods and preliminary criteria for target site/ stretch/area selection.

Cost: R300 000

Term: 2016–2017

Programme 4:

Water distribution and distribution systems

Interpretation of logging results as a water distribution system management tool

WRP Consulting Engineers (Pty) Ltd

1124



Project aim:

- Summarise the findings of this study in a practical, usable document that includes step-by-step guides to use logging results to identify and resolve water network problems

Cost: R300 000

Term: 2016–2017

Leakage characterization of bulk water pipelines

University of Cape Town

2572

Project aims:

- A literature review of the latest research on the relationship between pressure, leakage rate, and leakage area
- Design of equipment suitable for testing bulk pipelines
- Construction of the equipment and verification in the laboratory
- Pilot testing of the equipment on a bulk pipeline
- Testing several bulk pipelines of different materials, diameters and ages to determine their leakage characteristics
- Guidelines for condition assessment of pipelines using the methodology explained in this application

Cost: R1 335 000

Term: 2016 – 2019

Establishing the frequency and causes of contamination and intrusions in water distribution systems

University of Cape Town

2573

Project aims:

- A literature review of the latest research on contamination intrusion and its impact in water systems
- Establishing the frequency and magnitude of intrusion events and the characteristics of water distribution systems that contribute to these events
- Identify the critical aspects of intrusion mechanisms, including driving forces, contamination paths and contaminants near pipes
- Provide guidance on best practices of water quality control in water distribution systems using the Water Safety Plan (WSP) as a useful framework for risk assessment
- Develop expertise on water quality and hydraulics in water distribution systems

Cost: R750 000

Term: 2016 – 2018

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1:

Emerging treatment technologies – Preparing for the future

Mathematical modelling for trace elements and organic compounds in wastewater treatment plants in Gauteng

University of Johannesburg; Vaal University of Technology
2563

Project aims:

- To evaluate every stage of WWTP process in terms of heavy metals content; this will assist in getting the complete picture (mass balance) about the occurrence, fate and transport of heavy metals and organics
- To relate the process and controller dimensions for the WWTP units to retention time for the heavy metals
- To carry out in-depth sampling at the different WWTPs using different intervals based on retention time from liquid, mixed sludge and dewatered sludge
- To carry out experimental analysis of samples for heavy metals and organic substances to determine the load levels
- To mathematically model the heavy metal flow rates and the incidence of sludge production in the WWTP process; this will take into account hydraulic retention time (HRT) and loading rates.
- To simulate WWTP parameters using the CHEMCAD computer code/software to calculate the mass

balance based on the experimental data (results) obtained from the laboratory analysis

- To compare experimental results with simulated data from CHEMCAD in order to ascertain comparability of satisfactory results; this will allow for validation and parameter optimization
- To optimize parameters and validate empirical results through chemical modelling so as to ascertain comparability of satisfactory results
- To analyse the optimized results using chemometrics based on sum of square errors (SSE); after optimization, recommendations of the treatment process and the model will be completed and assessed for the activated sludge technology

Cost: R995 000

Term: 2016 – 2019

Development of a two-stage nitrification-Anammox process for improved ammonia removal from wastewater

Durban University of Technology; Columbia University
2565

Project aims:

- Identification of suitable growth/operational conditions to selectively enrich ammonia oxidising bacteria (AOB) and Anammox bacteria from mixed consortia



- Selective enrichment and optimization of growth conditions for AOB and Anammox bacteria in separate bioreactors
- Integration of enriched AOB and Anammox reactors into a two-stage continuous nitrification-Anammox process and evaluation of the potential for scale-up
- Comparison of the performance of the integrated (two-stage) reactor to the conventional single-stage Anammox reactor

Cost: R1 850 000

Term: 2016 – 2019

Getting the most out wastewater treatment plants and anaerobic digesters with biodegradability tests

University of Cape Town; University of KwaZulu-Natal (Howard College)

2595

Project aims:

- Modify the fully integrated physical, chemical and biological processes anaerobic digester (AD) simulation model developed in the previous WRC project (K5/1822) to simulate the BMP test
- Develop an augmented biomethane potential (ABMP) test experimental procedure to determine the unbiodegradable fraction and hydrolysis rate and composition (x, y, z, a, b, c in $C_xH_yO_zN_aP_bS_c$) of the biodegradable organics to predict AD performance
- Develop an augmented biosulphide potential (ABSP) test apparatus and procedure to determine unbiodegradable fraction and hydrolysis rate and composition of the

biodegradable organics without the error-prone gas measurements of the BMP and ABMP tests

- Build a settleometer to separate the settleable organics in municipal wastewater into different settling velocity groups
- Determine with the ABMP and ABSP tests the unbiodegradable fraction and hydrolysis rate and composition of the biodegradable organics of different settling velocity groups in municipal wastewater
- Code a primary settling tank (PST) model that begins to resemble reality by predicting higher removals of unbiodegradable organics (60–80%) than biodegradable organics (40–60%)
- Include the PST model into the fully integrated physical, chemical and biological processes plant-wide WWTP simulation model developed in the previous WRC project (K5/1822) to better predict activated sludge and AD system performance in plant-wide WWTPs

Cost: R1 800 000

Term: 2016 – 2020

Programme 2:

Application of appropriate technologies and tools

Treatment and reuse potential of urine and faecal fractions from urine-diversion dehydrating toilets in eThekweni Municipality

University of Kwazulu-Natal (Westville); eThekweni Municipality; Khanyisa Projects; Agriprotein

2586

Overall objective: To better understand the microbial risk associated with the beneficiation of faecal sludge from urine-diversion dehydrating toilets (UDDT) using black soldier fly larvae (BSFL) and struvite reactors. The benefits associated with reuse will be balanced against health risks associated with all stages of faecal sludge and urine handling and processing. Objectives are:

- To optimize, as far as practical, the conditions which promote the ability of BSFL to digest UDDT faecal sludge in a manner suitable for up-scaling to field conditions
- To optimize, as far as practical, the conditions which maximize the growth conditions of BSFL grown on mixed UDDT and a readily bioavailable organic substrate
- To measure levels of health-related organisms in UDDT faecal sludge, BSFL and BSFL-digested residual sludge, and to assess the health implications for householders, farmers and /or workers using processed by-products
- To monitor the fate of the pathogen indicators during urine processing, including measuring levels in struvite and struvite-depleted urine; this includes developing an understanding of how these respond to drying of struvite under different combinations of temperature and relative humidity
- To develop broad health-based guidelines on how UDDT faecal sludge and source-separated urine can be processed safely for beneficiation

Cost: R328 000

Term: 2016 – 2018

The implications of chemical composition of different types of greywater for seed germination and growth of crop plants

University of Kwazulu-Natal (Westville); eThekweni Municipality

2590

Project aims:

- Identify suitable greywater sources to be sampled, and suitable chemical techniques for investigating greywater composition; techniques should particularly address the presence of inorganic cations, and anionic, cations and non-ionic surfactants
- Measure seed germination, plant growth and plant physiological responses in response to irrigation with the greywater from sources identified above
- Assess the effect of simple treatment steps (probably on-site filtration through sand and gravel, or through biochar) on the chemical composition of different greywater types and on their effect on seed germination, plant growth and plant physiological responses
- Produce guidance to policy-makers, local authorities and users regarding which greywater types are best for irrigation, which constituents in greywater are the most harmful to plants and should therefore be avoided, and simple on-site treatment steps to mitigate adverse effects from constituents to plant growth

Cost: R345 000

Term: 2016 – 2018



Effects of reduction of wastewater volumes on sewerage systems and wastewater treatment plants

VitaOne8 (Pty) Ltd

2626

Project aims:

- To identify and quantify physical infrastructure based impacts on the conveyance and treatment systems resulting from drought and water conservation and demand management measures such as reduced wastewater influent flows and quality
- To identify and quantify operational and maintenance based impacts on the conveyance and treatment systems resulting from drought and water conservation and demand management measures using models such as the sewer network model and/ or WWTP model to map scenarios
- To assess health, environmental and financial impacts associated with both drought and water conservation and demand management measures such as reduced wastewater influent flows and quality
- To determine and identify practical adaptive interventions applicable for negative impact mitigation within the framework of the South African best practices and operational requirements
- To develop material which could be used to create awareness on drought and water conservation and demand management measures on wastewater services and proposed mitigation measures applicable within the South African municipal wastewater treatment industry

Cost: R300 000

Term: 2017

Programme 3:

Stormwater and sewerage systems

User interface design of communal ablution blocks (CABs) in urban South Africa

University of Cape Town; City of Cape Town Metropolitan Municipality

2569

Project aims:

- Develop improved design criteria for CABs, based on critical reflection on the user interface, informed by specialist ethnographic, engineering, architectural and industrial design expertise
- Develop prototypes of CABs
- Prepare design guidelines for CABs, for use in local authorities

Cost: R910 000

Term: 2016–2018

Securing water sustainability through innovative spatial planning and land use management tools – case study of two municipalities

i@consulting; North-West University (Potchefstroom)

2587

Project aims:

- To motivate that spatial planning legislation (Spatial Planning and Land Use Management Act, No. 16 of 2013) can become the backbone for a water-sensitive South Africa

- To address water-conscious land-use planning by re-evaluating the role of spatial planning in a water-sensitive manner
- Prove that water-sensitive planning is a short-term investment with long-term economic, social and environmental benefits for all municipalities
- Prove that integrating spatial planning and infrastructure planning (water) by means of land use planning can and will mitigate the demands on water resources
- Educate communities and stakeholders in clever water use, and reduce overall water demand
- Ensure a work-integrated learning environment for students in the spatial planning profession by gaining experience to be experts in their field of study (water-land relationship), and in this sense, enhancing the higher education sector's response to water-sensitive planning

Cost: R2 000 000

Term: 2016–2019

Assessment and control of inappropriate discharges into storm drains

Cape Peninsula University of Technology; City of Cape Town Metropolitan Municipality

2600

Project aims:

- Develop new procedures for identifying priority areas in urban sub-catchment with low, medium and high risk of inappropriate discharges

- Develop methodologies and techniques for identification, detection, monitoring and control of inappropriate discharges
- Collate data into a comprehensive guideline for assessment and control of inappropriate discharges into stormwater drains

Cost: R1 202 439

Term: 2016 – 2019

Programme 4:

Wastewater sludge and faecal sludge management

An investigation into the impact of sludge return flows on South African wastewater treatment works

Royal HaskoningDHV (Pty) Ltd

2581

Project aims:

- Assess the impact of the return flows from sludge handling/treatment (such as dewatering liquors and digestion rejection flows) in the WWTP biological treatment, i.e., aeration capacity, required biological volume and effluent quality
- Use the existing WRC plant-wide model to predict the impact of the sludge handling/treatment return flows on the biological treatment
- Identify the applicable technologies for nitrogen and phosphorus removal from return flows within the framework of South African best practices and operational requirements
- Identify the potential applications for recovered



nutrients, legal outlook and market value

- Cost balance for nutrient recovery solutions, including capital and operation costs, as well as sell earnings

Cost: R1 360 000

Term: 2016 – 2019

Programme 4:

Sanitation technology and innovations

Performance assessment of DEWATS constructed wetlands

University of KwaZulu-Natal (Howard College); eThekweni Municipality; BORDA; Asian Institute of Technology; Trinity College Dublin

2579

Project aims:

- Monitor the performance of the Newlands Mashu constructed wetlands
- Compare the performance with generally accepted design approaches
- Highlight gaps or shortcomings in the design techniques
- Provide guidance as to the design and operation of constructed wetlands serving dense social housing or informal settlements

Cost: R994 500

Term: 2016 – 2019

Drying and pasteurization of faecal sludge using solar thermal energy

University of KwaZulu-Natal (Howard College); eThekweni Municipality

2582

Project aims:

- Establish a solid bibliographic background on solar thermal energy and its application for faecal sludge processing
- Design, build and validate a solar drier prototype
- Characterize solar drying and pasteurization of the faecal sludge
- Establish guidelines for upgrading the system (e.g. costs, technical aspects, ideal locations for installation, use of the product)

Cost: R657 000

Term: 2016 – 2018

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 2:

Integrated management

A feasibility study to evaluate the potential of using water-sensitive design principles to strengthen water planning for the Waterberg Industrial Complex (or DM)

Golder Associates Africa (Pty) Ltd; Biomimicry SA; University of the Witwatersrand; University of Johannesburg

2765

Project aims:

- Provide a baseline assessment of the Waterberg catchment
- Using a set of tools designed as part of the Watershare partnership, develop a conceptual water -sensitive design for the area which integrates water resource protection and supply, stormwater management, wastewater treatment and biodiversity protection
- Engage and share water-sensitive design concept, framework and guidelines with relevant stakeholders and ensure buy-in of all stakeholders through project cycle
- Set specific WSD WQ objectives for the selected area with realistic design and performance objectives; a comparative analysis between conventional design objectives and WSD objectives should be done
- Screen and evaluate feasibility of implementing the WSD options in the Waterberg District Municipality

and with current catchment partners by assessing amongst others the institutional arrangements, the planning and management practices, and the appropriate technology options available to meet design, cost and performance objectives

- Link knowledge and partnerships to WRC Community of Practice Programme in this domain (hosted by UCT Urban Water Management Research Unit on behalf of the WRC)

Cost: R1 368 000

Term: 2017 – 2019

Programme 3:

Quantification, prediction and minimisation of water use and waste production

Brine systems and treatment processes

University of Cape Town; Eskom; Environmental and Nanosciences Research Group; University of Istanbul

2576

The main aim of the research is to review, characterize and model a range of South African brines and wastewaters with a view to evaluating suitable treatment technologies. This will be achieved as follows:

- Review the current state of South African brines, including their composition and location
- Select a suite of representative South African brines (as recommended in the WRC/Eskom workshop) and



carry out a full water characterisation on each of the brines

- Carry out a thermodynamic analysis of the case study brines and proposed potential treatment processes
- Work in collaboration with Eskom in order to establish which of the brines are suitable for treatment using EFC technology

Cost: R2 004 283

Term: 2016 – 2019

Programme 4:

Governance, policy, regulatory, and economic instruments to improve industrial water management

Description and quantification of drought shocks in South African industries

The Pegasys Institute NPC

2604

This project aims to quantify the impacts of droughts on South African industries, including agriculture but also outside of agriculture, in terms of impacts on production, cost of raw materials, export earnings, unemployment, profits, real non-indexed wages, consumption of products, and investment, among others. The outputs of the project (8 fact sheets), will be used with targeted industries and institutions in providing compelling reasons to act early in the event of meteorological drought warnings. The 8 fact sheets will be based on an extensive literature review and economic analysis of the impact of drought on different sectors in South Africa. The study will also consider the

different hydro-climatic zones of South Africa, and the divergent nature of droughts within these areas. By describing the societal and economic impacts of a drought on particular sectors and regions, improved actions to mitigate the potential impacts will be possible. Overall, the expected impact of the above outcomes will be a more proactive and responsive suite of sectors of the economy in relation to drought in the future.

Cost: R600 000

Term: 2016 – 2017

Programme 5:

Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Photo-PROTEA

University of the Western Cape; French National Centre of Scientific Research; Cape Peninsula University of Technology

2562

Project aims:

- Assess the efficiency of the Life-Phytobarre bioremediation process on Western Cape winery and olive-mill wastewaters
- Study the evolution of the microbial communities according to the type of waste (winery and olive-mill), and relate to seasonal changes
- Identify if indigenous microorganisms participate in the biodegradation; isolate the key organisms and then reformulate the initial photosynthetic bacterial consortium

- Set up an outdoor lab-scale experiment to establish a proof-of-concept on a 100 L volume capacity

Cost: R700 000

Term: 2016 – 2019

Electrochemical unit operations in industrial wastewater treatment: the development of electrocoagulation and photoelectrochemical oxidation reactors based on novel nanocomposite electrodes

University of Johannesburg; Radical Waters; University of the Western Cape; University of Bath; University of Campinas

2567

Project aims:

- The general aim is to develop and integrate electrocoagulation and photoelectrochemical oxidation unit operations based on novel mixed nanomaterials into a reactor system for the treatment of industrial wastewater
- To incorporate electrocoagulation as a unit operation into water treatment in a jar test experiment
- To evaluate the performance (metal removal, COD removal, turbidity removal etc) of electrocoagulation over coagulation using simple electrode configuration and novel carbon cathode
- To understand the morphology, chemical and electrochemical behaviours of novel nano-carbon materials and composites for photoelectrochemical oxidation

- To understand the applicability of these materials as photoanodes and cathodes under various conditions as it relates to wastewater treatment
- To evaluate the performance of photoelectrochemical oxidation unit operation in a jar test experiment for wastewater treatment
- To evaluate the efficiency of (solar) photoelectrochemical reactors developed from these materials in the presence of selected standard dye/ organic polluted water and real sample wastewater
- To interrogate the kinetics, degradation products and mechanism of the degradation processes
- To generate data that can explain the performance of a pre-pilot reactor consisting of both electrocoagulation and photoelectrochemical unit operations towards different types of wastewater
- To study the effect of different reactor configurations based on different material combinations

Cost: R160 000

Term: 2016 – 2019

Reclamation of industrial process water from solid and liquid effluents, through integrated bio-energy production

Stellenbosch University; Elgin Fruit Juices (Pty) Ltd; Paper Manufacturers of South Africa

2570

Project aims:

- To design and construct an experimental anaerobic biodigester module consisting of 8 x 50 L reactors;



no such experimental system exists in SA, and will serve this project as well as several to follow very well, leading to greater industrial roll-out of the technology

- To develop and scale up the optimised process developed (in a different investigation) for production of bioethanol from a range of paper sludge wastes to 100 L bioreactor scale
- Determine potential biogas yield from paper sludge wastes, and from fermentation residues remaining after bioethanol production from each of these feedstocks, using 50 L reactors
- Characterise the final residues (solid and liquid components) of anaerobic biodigestion and determine the suitability for, and extent of water reclamation, and suitability of water and solid residues from these biofuel production processes for industrial and/or agricultural application
- Determine energy yield from combustion of solid residues of anaerobic biodigestion
- Stakeholder engagement in the fruit industry in the Western Cape, to determine the scope and level of buy-in for ethanol production from fruit wastes

Cost: R1 000 000

Term: 2016 – 2019

Water recovery from flue gas evaluation

University of the Western Cape (SAIAMC); DNV GL;

Eskom

2571

Project aims:

- Modification of a laboratory-scale testing facility
- Produce laboratory-scale membrane modules suitable for water recovery from model flue gas
- Completion of a flue gas treatment facility
- Produce upscaled membrane modules suitable for water recovery from flue gas
- Integration of the flue gas facility into the Lethabo power station
- Demonstrate the water recovery from real flue gas using the integrated gas treatment facility at Lethabo power station

Cost: R3 670 000

Term: 2016 – 2019

Optimising the use of fish to harvest algae from industrial effluent treatment ponds

Rhodes University

2574

Project aims:

- Develop a process that makes the algae in post-high rate algal ponds more available to fish
- Optimize the process of converting algal biomass into fish biomass, so that we are in a position to pilot the technology

Cost: R550 000

Term: 2016 – 2018

Smart bio-nanocomposites for organic dye remediation

UNISA (Florida)

2583

The main aim of the project is to develop smart bio-nanocomposites for organic dye remediation which will involve a visible light driven photocatalyst based on rare earth doped carbon nanotubes and titania, immobilised on biopolymers such as chitosan, alginate, cyclodextrins, etc. This photocatalyst will be evaluated for the degradation of various azo dyes. The aim of the project will be addressed through the following specific objectives which are:

- To prepare rare earth (Eu, Gd, Ce, Nd, La, etc.) doped carbon nanotubes via a simple wet impregnation

method followed by thermal decomposition and reduction in hydrogen

- To prepare rare earth doped carbon nanotube/ titanium dioxide nanocomposites via a sol gel method
- To immobilise the rare earth doped carbon nanotube and rare earth doped carbon nanotube/titania on biopolymers using crosslinking agents such as hexamethylene diamine and gluteraldehyde
- To evaluate the bare and polymer immobilised photocatalysts for the degradation of various azo dyes in synthetic solutions under visible light irradiation

Cost: R900 000

Term: 2016 – 2019

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1:

Water use and waste production

Irrigation with poor quality mine water in Mpumalanga

University of Pretoria; University of the Free State
(Institute for Groundwater Studies)

2564

Project aims:

- To identify key considerations for locating

intermediate- to large-scale mine water irrigation schemes in the landscape based on geo-hydrological characteristics, and identification of monitoring requirements and thresholds for action for such schemes

- To assess, on a small experimental scale, the use of untreated acid mine drainage (AMD) on limed soil, limed and clarified AMD, and limed and unclarified AMD still containing metal hydroxide sludge on crop growth and soil properties
- To monitor and model field-scale water and salt



balances for two small-scale mine-water irrigation schemes (30 ha on rehabilitated land and 30 ha on unmined land) in Mpumalanga, in order to predict the long-term impact and sustainability of mine-water irrigation

- To quantify the economic sustainability of irrigation with mine-water

Cost: R6 200 000

Term: 2016 – 2021

Programme 3:

Minimising waste production

An assessment to determine if pit lakes are a solution to coal mine closure in South Africa

GCS Water and Environment (Pty) Ltd; University of the Free State (Institute for Groundwater Studies)

2577

Project aims:

- Identify six existing pit lakes for the field investigation of water quality, temperature, pH, ORP and dissolved oxygen
- Determine if final mine voids (pit lakes) are a viable option for coal mine closure in South Africa
- Develop a guideline for the design of coal mine pit lakes in South Africa

Cost: R1 240 350

Term: 2016 – 2019

Resource efficient and socially responsible approaches for the integrated management of mine waste: Understanding the opportunities, enablers, barriers and risks

University of Cape Town

2580

Project aims:

- Identify key opportunities, drivers, enablers and barriers for the valorisation of mine waste in the South African context
- Establish potential roles of the relevant stakeholders (government, mining industry, SMEs) in enabling the implementation of effective management approaches for mine wastes
- Develop a more detailed understanding of the inter-relationship between mine waste, environmental degradation and community impacts (health and livelihoods)
- Enhance current tools for assessing the potential metal and salt-related risks posed by coal wastes, and build an inventory database for such wastes in the local context

Cost: R1 277 837

Term: 2016 – 2018

Programme 4:

Mining in the 21st century

Development and application of new materials for selective removal of trace elements from mine wastewater

University of the Witwatersrand; CANSA; Impala Platinum Ltd

2589

Project aims:

- To assess the water quality in water systems impacted by mining activities (gold and platinum mining).
- To modify and functionalise natural zeolite and bentonite using various ligands based on pollutants and precious metals
- To conduct static (batch) studies using natural and functionalised zeolite and bentonite for synthetic and environmental samples
- To conduct dynamic (column) studies using natural and functionalised zeolite and bentonite for synthetic and environmental samples
- To conduct desorption studies to assess the potential re-usability of the adsorbents
- To conduct chemometric and geochemical modelling to characterize water quality and to assess long-term aspects
- To deploy the adsorbents to impacted mining sites

Cost: R862 250

Term: 2016 – 2019

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