International Specialised Skills Institute

Wastewater Treatment: Remote Control and Monitoring

Paul Gray

Skills Victoria Veneto (Italy) International TAFE Fellowship

Fellowship funded by Skills Victoria, Department of Innovation, Industry and Regional Development, Victorian Government

Victoria
The Place To Be

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Executive Summary

The Fellowship allowed Paul Gray the opportunity to attend the International Water Association (IWA) conference Small Sustainable Solutions for Water (SSS 4 WATER). The conference was held at the International University of Venice, on the island of San Servolo, Venice, Italy in April 2011. SSS 4 WATER was hosted and organised by the Ministry of Infrastructure and Transport in conjunction with the Venice Water Authority. It encompassed three conferences:

- 10th Specialized Conference on Small Water and Wastewater Treatment Systems
- 4th Specialized Conference on Decentralized Water and Wastewater International Network
- 3rd Specialized Conference on Resources Oriented Sanitation.

The Fellow attended numerous presentations and gained first-hand knowledge on:

- Wastewater treatment by means of decentralised wastewater treatment plants.
- Technical problem solving by remote monitoring and control of these systems.
- Locating treatment plants within world-renowned existing buildings.
- Water quality and equipment performance by remote control monitoring.

The Fellow undertook several site visits that included:

- The Membrane Bio Reactor (MBR) treatment plant on the island of Sant'Erasmo.
- The wastewater treatment plant in Treviso.
- The MBR treatment plant in the Hotel Danieli.
- The MBR treatment plant in the Hilton Molino Stucky Venice hotel.
- The San Giorgio di Nogaro treatment plant.
- The Venice Water Authority.
- The MOSE Project (Modulo Sperimentale Elettromeccanico [Experimental Electromechanical Module] Project).

The focus of these visits centred on decentralised wastewater treatment plants, the monitoring and control of these plants by a remote computer generated system and the reuse of treated wastewater.

With Australia being one of the driest continents on earth, it would be prudent to adopt these technologies as we can ill afford to continue to use one of our most precious commodities, our drinking water, as if we had an infinite supply. Our fresh water is used to irrigate non-food crops, to hose down factory floors, cool machinery in manufacturing processes and in many other instances where treated wastewater could achieve the same result in a more responsible and sustainable manner.

The remote monitoring and control of wastewater treatment plants on an individual basis or the remote monitoring and control of numerous decentralised wastewater treatment plants from a centralised position has a proven economical foundation with energy savings in the vicinity of 30% per annum. Industry and the community would benefit with the adoption and implementation of this mode of technology. As with any new product, education and training is the key to the understanding and acceptance of these new technologies.

The skills and knowledge gained by the Fellow will be disseminated throughout Technical and Further Education (TAFE) institutes by means of the Plumbing Training Moderation Group of Australia. Presentations will be delivered to Certificate III students as well as industry representatives currently undertaking Certificate IV. Up-to-date information will also be included in resources CPCPDR 2002A Install Domestic Treatment Plants, CPCPDR 2003A Maintain Effluent Disinfection Systems & CPCPDR 3003A Install Onsite Disposal Systems.

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Abbreviations/Acronyms

cm/d	cubic meters per day
EBPR	Enhanced Biological Phosphorus Removal
EMS	Environmental Management System
GSM	Global System for Mobile Communication
HSSF	Horizontal Sub-Surface Flow
ISS Institute	International Specialised Skills Institute
IWA	International Water Association
MBR	Membrane Bio Reactor
MOSE Project	Modulo Sperimentale Elettromeccanico (Experimental Electromechanical Module) Project
NMIT	Northern Melbourne Institute of TAFE
PC	personal computer
SBR	Sequencing Batch Reactor
SSS 4 WATER	Small Sustainable Solutions for Water conference
SWWTP	Small Waste Water Treatment Plants
TAFE	Technical and Further Education
um	micrometer (equivalent to .001 millimetres)
VSSF	Vertical Sub-Surface Flow

Definitions

Aerobic digestion
The process of oxidising and decomposing the organic part of the sludge by microorganisms in the presence of oxygen.

Anaerobic digestion
A bacterial process that is carried out in the absence of oxygen.

Anoxic
Absence of oxygen

Bio-gas
A mixture of methane and carbon dioxide, generated when bacteria degrade biological material in the absence of oxygen in the process known as anaerobic digestion.

Denitrification
The biological reduction of nitrate to nitrogen gas by facultative heterotrophic bacteria. Facultative bacteria can get their oxygen by taking dissolved oxygen out of the water or by taking it off nitrate molecules. Denitrification occurs when oxygen levels are depleted and nitrate becomes the primary oxygen source for microorganisms.

Design
Design is problem setting and problem solving. Design is a fundamental economic and business tool. It is embedded in every aspect of commerce and industry and adds high value to any service or product—in business, government, education and training, and the community in general.[1]

Gatoli
conduits

Innovation
Creating and meeting new needs with new technical and design styles. (New realities of lifestyle).[2]

Inox steel
stainless steel

kWh
Kilowatt hour. Energy is a measure of how much fuel is contained within something or used by something over a specific period of time.

Mesophilic
37 degrees Celsius

Methane
principal component of natural gas

MOSE Project
The MOSE Project (acronym for Modulo Sperimentale Elettromeccanico — in English, Experimental Electromechanical Module) is a project intended to protect the city of Venice, Italy, from floods. The project is an integrated defence system consisting of rows of mobile gates able to isolate the Venetian Lagoon from the Adriatic Sea when the tide reaches above an established level (110 cm) and up to a maximum of 3 m.[3]

Nitrification
The biological conversion of ammonia to nitrate nitrogen. Bacteria known as nitrosomonas convert ammonia and ammonium to nitrate. Next bacteria called nitrobacteria finish the conversion of nitrite to nitrate. These bacteria must have free dissolved oxygen to perform their work.

Oxic
with oxygen

Oxidation
adding of oxygen

Skill deficiency
A skill deficiency is where a demand for labour has not been recognised and training is unavailable in Australian education institutions. This arises where skills are acquired on-the-job, gleaned from published material or from working and/or studying overseas.[4]

There may be individuals or individual firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the intellectual property to themselves. Over time these individuals retire and pass away. Firms likewise come and go.

Sustainability
The ISS Institute follows the United Nations for Non-Governmental Organisations' definition on sustainability: *"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*.[5]

Thermophilic
55 degrees Celsius

Acknowledgements

Paul Gray would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body – International Specialised Skills Institute (ISS Institute)

The International Specialised Skills Institute Inc is an independent, national organisation that for over two decades has worked with Australian governments, industry and education institutions to enable individuals to gain enhanced skills and experience in traditional trades, professions and leading-edge technologies.

At the heart of the ISS Institute are our Fellows. Under the **Overseas Applied Research Fellowship Program** the Fellows travel overseas. Upon their return, they are required to pass on what they have learnt by:

1. Preparing a detailed report for distribution to government departments, industry and educational institutions.
2. Recommending improvements to accredited educational courses.
3. Delivering training activities including workshops, conferences and forums.

Over 200 Australians have received Fellowships, across many industry sectors. In addition, recognised experts from overseas conduct training activities and events. To date, 22 leaders in their field have shared their expertise in Australia.

According to Skills Australia's 'Australian Workforce Futures: A National Workforce Development Strategy 2010':

> Australia requires a highly skilled population to maintain and improve our economic position in the face of increasing global competition, and to have the skills to adapt to the introduction of new technology and rapid change.
>
> International and Australian research indicates we need a deeper level of skills than currently exists in the Australian labour market to lift productivity. We need a workforce in which more people have skills, but also multiple and higher level skills and qualifications. Deepening skills across all occupations is crucial to achieving long-term productivity growth. It also reflects the recent trend for jobs to become more complex and the consequent increased demand for higher level skills. This trend is projected to continue regardless of whether we experience strong or weak economic growth in the future. Future environmental challenges will also create demand for more sustainability related skills across a range of industries and occupations.[6]

In this context, the ISS Institute works with Fellows, industry and government to identify specific skills in Australia that require enhancing, where accredited courses are not available through Australian higher education institutions or other Registered Training Organisations. The Fellows' overseas experience sees them broadening and deepening their own professional practice, which they then share with their peers, industry and government upon their return. This is the focus of the ISS Institute's work.

For further information on our Fellows and our work see http://www.issinstitute.org.au.

Fellowship Sponsor

The Victorian Government, Skills Victoria is responsible for the administration and coordination of programs for the provision of training and further education, adult community education and employment services in Victoria and is a valued sponsor of the ISS Institute. Gray would like to thank them for providing funding support for this Fellowship.

Supporters

- Gary Bath, Manager Practitioner Development, Plumbing Industry Commission
- Brent Papadopoulos, Managing Director, Sustainable Plumbing Solutions
- Joan Whelan, Project Manager, Construction & Property Services Industry Skills Council (CPSISC)

Employer Support

Paul Gray wishes to acknowledge the Northern Melbourne Institute of TAFE (NMIT) for the time and funds afforded to him to participate in the Fellowship.

Organisations Impacted by the Fellowship

Government

- CPSISC
- Plumbing Industry Commission
- State and local sewerage authorities
- Sustainability Victoria

Industry

- Huber technology, Germany
- Master Plumbers Association
- Sustainable Plumbing Solutions

Professional Associations

- International Water Association (IWA)
- Plumbing Trades Employees Union

Education and Training

- Flinders University, South Australia
- National Plumbing Services Training Advisory Group
- Plumbing Training moderation Group Australia
- University of Verona, Italy
- Victorian Plumbing Training Managers Committee

About the Fellow

Name: Paul Gray

Employment

- Program Co-ordinator Plumbing, NMIT

Qualifications

- Certificate IV Training and Assessment TAE40110, MRWED, 2011
- Working at Heights License, Workplace Assessment Management, 2010
- License to perform High Risk Work Boom Elevated Work Platform, Work Safe, 2010
- Certificate IV Plumbing Services, Bendigo Regional Institute of Technical and Further Education (TAFE), 2009
- Certificate IV Training and Assessment TAA40104, NMIT, 2008
- Construction Industry Card, NMIT, 2006
- Certificate IV Training and Assessment BSZ40198, Box Hill Institute of TAFE, 1996
- Diploma Technical Teaching, Hawthorn Institute of Education, 1989
- Certificate I, II & III Manual Metal Arc Welding, Preston College of TAFE, 1988
- Registered and Licensed Plumber Board of Health and Metropolitan Board of Works, 1975

Memberships

- Plumbing Industry Commission
- Victorian Plumbing Training Managers Committee

Brief Biography

Gray completed his four-year plumbing apprenticeship in 1974 and worked in the industry until 1985 as a plumbing practitioner, foreman and contractor. He commenced his teaching career at Preston East Technical School in 1986 then moved into apprenticeship training in 1988.

After 12 years teaching apprentice plumbers, Gray took on a position with the Plumbing Industry Commission in their Assessment section where he continued his involvement with apprentice training for a further nine years. During that time the Fellow was selected as an industry expert to conduct, in conjunction with Skills Victoria, a Strategic Industry Audit of apprenticeship training across the state of Victoria. In 2008 Gray was appointed Program Co-ordinator of Plumbing at NMIT, a position in which he continues at the present time.

Aims of the Fellowship Program

The aim of the Fellowship program was to provide the Fellow with the opportunity to experience state-of-the-art facilities and world's best practice in wastewater collection and treatment, in particular:

- Remote control and monitoring of multiple small wastewater treatment plants.
- Remote control of a centralised wastewater treatment plant and the associated economical benefits.
- A treatment plant within an agricultural community with its treatment basins below ground to blend in to the surrounding landscape.
- Innovative approaches to problem solving and production improvement of municipal waste and wastewater treatment in other countries.
- Upgrading of small wastewater treatment plants.
- Membrane Bio Reactors (MBRs).

The Australian Context

The plumbing industry plays an important role in safeguarding public health specifically in the areas of water quality and sanitation.

The Plumbing industry is one that encompasses a wide and varied range of disciplines and expertise. There are eight main classes of plumbing. These are as follows:

- Drainage
- Fire Protection
- Gas Fitting
- Irrigation
- Mechanical Services
- Roofing
- Sanitary
- Water Supply

There are also 15 restricted classes and five specialised classes of plumbing practice. The restricted classes are as follows:

- Hydrants & Hose Reels
- Residential & Domestic Fire Sprinklers
- Commercial & Industrial Fire Sprinklers
- Fire System Pump Sets
- Gas – Disconnect & Reconnect
- Gas – Restricted to Type A Appliances
- Gas – Mobile Homes
- Solid Fuel Heaters
- Duct Fixing
- Single Head Split Systems
- Class 10A Roofing
- Domestic Hot Water Services
- Refrigeration – Air-conditioning (Basic)
- Refrigeration – Air-conditioning (Intermediate)
- Refrigeration – Air-conditioning Split Systems

The specialised classes are as follows:

- Gas – Servicing Type A Appliances
- Gas – Conversion Type A Appliances
- Type B Gas Fitting
- Type B Gas Fitting Advanced
- Refrigeration Air-conditioning
- Backflow Prevention

By the very nature of the work, the plumbing industry as a whole plays a major role in safeguarding public health, specifically in the areas of water quality and sanitation, as well as gas fitting. In order to maintain these values the plumbing practitioner must provide a Certificate of Compliance to demonstrate their work complies with the relevant Australian Standards and must also guarantee the quality of their workmanship for a period of six years. The role of the plumber is an important one that should not be taken for granted by the practitioner or the public in general.

Although the CPC08 Plumbing Services training package delivered in TAFE institutes contains competencies CPCDR2002A Install Domestic Treatment Plants and CPCDR2003A Maintain Effluent Disinfection Systems, the training does not address wastewater collection and treatment with a view to the monitoring of the treatment and the reuse of the treated water. There is a gap in training that needs to be addressed. The education of apprentices who will become our tradespeople of tomorrow is the perfect vehicle to drive this initiative of decentralised wastewater collection and treatment for domestic and industrial applications.

The realisation that our drinking water is not an endless supply has raised our consciousness for the need to reuse treated water where appropriate.

Wastewater can be treated by a MBR treatment plant, which involves removing pollutants from the wastewater to enable its reuse. This technology coupled with the remote control and monitoring of the treatment plant will accomplish not only a saving of our natural resource but also an economic saving.

SWOT Analysis

Strengths

- Decentralised wastewater treatment collection and treatment requires less infrastructure.
- Remote monitoring and control has economical advantages.
- Demand for drinking water conservation.
- Demand for sustainable solutions.
- Ability to establish ongoing International networks.
- Remote control and monitoring of centralised wastewater treatment plants has an energy saving of up to 30% per annum.[7 8]

Weaknesses

- Industry reluctance to change and embrace new technologies.
- Lack of public acceptance of new technologies.
- Lack of government incentives and support.
- Little, if any, research and development.
- Limited training available.

Opportunities

- New markets and opportunities for industry operatives.
- New markets and opportunities for suppliers.
- New training development.
- Ability to develop research and establish links with International world's best practice companies and personnel.

Threats

- Community reluctance to reuse treated water.
- Apathy to the conservation of our drinkable water.
- Government inaction on the conservation of our drinkable water supply.
- Installation by untrained and or unqualified personnel.

Identifying the Skills Deficiencies

1. **Knowledge and understanding of decentralised wastewater collection and treatment.**

- System types, selection and location suitability.
- System operation parameters.
- Maintenance and repair.
- Innovative approaches to technical problem solving.

Action: To identify and better understand the types of systems available, enabling a systematic approach to selection, location, operation, maintenance and repair.

2. **Evaluation methods for determining appropriate alternative onsite collection and treatment systems to be integrated with existing systems that discharge all wastewater and sewage to a remote treatment facility.**

- Designing alternative and integrated onsite collection systems requires plumbing practitioners to have the methods to evaluate appropriate and suitable systems.
- The implementation of this technology is prevalent overseas leading to information sharing and the availability of training. As it is not in common use in Australia, there exists a proportionately low knowledge base.

Action: Identify methods to log site particulars and evaluate conditions to determine appropriate system selection.

Action: Increase the knowledge base by forming networks with International world's best practice companies and university research engineers.

3. **Latest equipment and technological advances.**

- State-of-the-art systems.
- Current world-renowned expertise.
- Water quality.
- Monitor equipment performance.
- Remote control system monitoring and control.

Action: To identify world's best practice that encompasses the latest technology coupled with state-of-the-art treatment methods allowing industry to adopt a modern approach including equipment and treatment plant performance via a remote controlled monitoring system.

The International Experience

Destination: SSS 4 WATER Conference

Location

- The International University of Venice on the island of San Servolo, Venice, Italy.

The IWA conference Small Sustainable Solutions for Water (SSS 4 WATER) was hosted and organised by the Ministry of Infrastructure and Transport, and the Venice Water Authority. It encompassed three conferences:

- 10th Specialized Conference on Small Water and Wastewater Treatment Systems
- 4th Specialized Conference on Decentralized Water and Wastewater International Network
- 3rd Specialized Conference on Resources Oriented Sanitation.

Conference venue

Island of San Servolo

Contacts

- Dr Laurence Gill, Head of Department, Department of Civil, Structural and Environmental Engineering, Senior Lecturer, University of Dublin.
- Eran Friedler, Associate Professor, Department of Environmental, Water and Agricultural Engineering, Israel Institute of Technology.
- Francesco Fatone, Assistant Professor, Department of Biotechnology, University of Verona.
- David Balzonella, Assistant Professor, Department of Biotechnology, University of Verona.
- Nick Meeten, Team Leader Green Buildings, Huber Technology, Waste Water Solutions, Germany.
- Neil Buchanan, Environmental Health and Science Engineering, Flinders University, Adelaide, South Australia.
- Joe Whitehead, Director, Centre for Environmental Training, University of Newcastle.
- Bill McCann, Contributing Editor, Water 21.
- Dr Paolo Pavan, Professor of Chemical Engineering, University of Venice.

Platform Presentations

The SSS 4 WATER conference was held at The International University of Venice on the island of San Servolo, Venice, Italy, and included presenters from all over the world. The platform presentations attended by the Fellow as part of the conference are listed on the following page.

- 'Extensive and Natural Systems for Small Water and Wastewater Systems' by Marcos von Sperling, Federal University of Minas Gerais, Brazil.
- 'Ecological and Resource Oriented Sanitation in Developing and Developed Countries' by Grietje Zeeman, Wageningen University, the Netherlands.

Theme: Nutrients Removal in Small Systems

- 'Understanding the Detrimental Effect of Nitrate Presence Under Anaerobic Conditions in an Enhanced Biological Phosphorus Removal (EBPR) System' by Javier Guerro, Department of Engineering, University of Barcelona, Spain.

Theme: On Site Water and Wastewater Treatment

- 'Biosand Filter: Enhancement of the Hydraulic Performance Using Alternative Filter Medium' by Kebreab Ghrebremichael, UNESCO-IHE, Delft, the Netherlands.
- 'Recycled Glass Compared to Sand as a Media in Polishing Filters for On-site Wastewater Treatment' by P L Veale, Trinity College Dublin, Ireland.
- 'Onsite Wastewater Nitrogen Reduction with Expanded Media and Elemental Sulphur Biofiltration' by Daniel Paul Smith, American Society of Civil Engineers, the United States of America.
- 'Managing On-site Wastewater Management Systems and Their Contribution to Water Quality in Gippsland, Australia' by Joe Whitehead, University of Newcastle, Australia.
- 'Recent Developments in On-site Wastewater Treatment Legislation for Ireland' by Dr Laurence William Gill, Trinity College Dublin, Ireland.
- 'On-site Wastewater Treatment System: Efficiency at Long Term and Behavior of Sand Filter in Great Variations of Organic and Hydraulic Loads' by Abdelkader Lakel, CSTB-AQUASIM Centre for Scientific & Technical Construction, France.

Theme: Stormwater and Groundwater Management

- 'The Characteristics of Rainfall Runoff in the Venice Area and the Actions of the Venice Water Authority for Stormwater Management' by Giorgio Ferrari, Venice Water Authority, Venice, Italy.
- 'Stormwater Collection and Management: Innovative Installation in Large Infrastructures' by Stefano Biondi, Stormwater Italia, Venice, Italy.

Theme: Extensive and Natural Systems

- 'Influence of High Organic Loads During the Summer Period on the Performance of Hybrid Constructed Wetlands (Vertical Sub-Surface Flow [VSSF] + Horizontal Sub-Surface Flow [HSSF]) Treating Domestic Wastewater in the Alps Region' by Angela Ortigara, Department of Civil and Environmental Engineering, University of Trento, Italy.
- 'Comparison of a High Rate Algal Pond with a "Standard" Secondary Facultative Waste Stabilisation Pond in Rural South Australia' by Neil Buchanan, Flinders University, Adelaide, South Australia.
- 'Solids, Organic Matter and Pathogens Removal Performance by Primary Facultative Stabilization Ponds' by Tsunao Matsumoto, Universidade Estadual Paulista, Brazil.

Theme: Water Reuse and Resource Recovery

- 'Resource Recovery from Black Water: Total Concept and Outlook' by Marthe de Graaff, Environmental Technology, Wageningen Institute for Environment and Climate Research, the Netherlands.
- 'Potential Impacts of On-site Greywater Reuse in Landscape Irrigation' by Dr Eran Friedler, Israel Institute of technology, Israel.

- 'Grey Water Treatment Concept Integrating Water and Carbon Recovery and Removal of Micropollutants' by Lucia Hernandez Leal, Wetsus (Centre for Sustainable Water Technology), Wageningen University, the Netherlands.

Theme: Sequencing Batch or Intermittently Aerated Bioreactors

- 'Small Wastewater Treatment Plants: Modelling and Real Results of the Alternate Cycles Process' by Barbara Paci, Italian National Research Council Rome, Italy.
- 'Treatment of Strong Nitrogenous Wastewater in a Small Sequencing Batch Reactor (SBR) for the Short-cut Nitrogen' by Francesco Fatone, Department of Biotechnology University Verona, Italy.
- 'MBR and SBR Decentralized Treatment Plants for the City of Venice. Reliability and Efficiency Analysed Through a Remote Control System' by Sebastiano Carrer, Anti Pollution Department, Magistrato alle Acque Venice, Italy.

Theme: Planning and Policy

- 'Environmental Management System (EMS) for Biosolids Composting "A Canadian Success Story"' by Richard Roland, Greater Moncton Sewerage Commission, Canada.
- 'A Territorial Approach for Excess Sludge Management: the Case of Autonomous Province of Trento' by Willj Merz, Wastewater Treatment Agency, Trento, Italy.
- 'Stochastic Modeling to Identify Requirements for Centralized Monitoring of Distributed Wastewater Treatment' by Thomas Hug, Swiss Federal Institute of Aquatic Science and Technology, Switzerland.
- 'The Decentralized Wastewater Treatment System of the City of Venice Leads to the Improvement of Water Quality in its Canals' by Elisabetta Tromellini, the Venice Water Authority, Venice, Italy.

Theme: Membrane Technology

- 'From Conventional Small Waste Water Treatment Plants (SWWTP) to Small MBR opportunities in Flanders' by Kathleen Moons, Aquafin wasterwater treatment company, Belgium.

Theme: Area Studies – Case Studies

- 'Management of Decentralized Waste Water Treatment Plants in Venice. Analysis of Costs and Efficiency' by Sebastiano Carrer, Venice Water Authority, Venice, Italy.
- '"Leflor" Horizontal Flow Drying Beds: a Solution for a Territorial Sludge Management' by Giovanni Sacchiero, Engineers Board of the Province of Vicenza, Venice, Italy.

Theme not Specified

- 'Sequencing Batch Reactors for Small Municipal and Industrial Wastewater Treatment' by Roberto Ramadori, Water Research Institute, Rome, Italy.

Objective

The Fellow's objective in attending the SSS 4 WATER conference was to gain first-hand knowledge of world's best practice in:

- Wastewater treatment by means of decentralised wastewater treatment plants
- Technical problem solving by the remote control monitoring of these systems
- Locating the treatment plants within existing buildings
- Maintenance and repair
- Water quality and equipment performance by remote control monitoring.

The sewage system of Venice was designed and built during the eighteenth century by the Serenissima Republic and it still exists today. It consists of an intricate network of underground conduits called 'gatoli' where wastewater from buildings was collected and discharged into the nearest canal or the Venetian Lagoon. The pipe work is normally located .75 meters below the average sea level allowing for both settling and flushing of the wastewater. The sludge would settle in these gatoli and during high tide the water from the canals would rise and flush the contents of the gatoli into the canals. Once in the canals more settling would take place; whereas, the dissolved fraction would be conveyed into the open Venetian Lagoon then out to sea. This is a rudimentary sewage system where the anaerobic process takes place inside the gatoli as the pipe work having no fall acts as a septic tank until the next high tide flushes its contents. The aerobic process takes place in the canals and Venetian Lagoon and disinfection occurs naturally by the seawater.

This simple disposal system has been very efficient throughout the centuries; however, industrial and economic development in the late nineteenth century have had a negative impact on the Venetian Lagoon resulting in the system being no longer viable.

In the 1970s the economic structure of the city of Venice changed radically with a decrease in industry and a boom in tourist activity resulting in more than 20 million tourists visiting Venice, especially the historical city centre, per year. These changes resulted in a marked difference in both the make up of the wastewater and the load placed on the existing system. Any attempt at constructing a centralised sewerage system able to convey wastewater to the mainland's plants proved too difficult and not sustainable.

The poor environmental health of the canals and Venetian Lagoon in 1988 proved to be dramatic, with laws requiring the implementation and introduction of treatment plants being largely ignored. In 1990 and 1995 two new acts were passed giving the Municipality of Venice direct control over waste management. In particular, law 206/95, which stated that individual waste treatment was compulsory. As far as domestic discharge was concerned, for agglomerations less than the equivalent population of 100 people a primary treatment plant such as a septic tank was sufficient, while for agglomerations greater than the equivalent population of 100 people wastewater aerobic treatment plants were required. No discharge was allowed until permission had been granted by the Magistro alle Acqua, the authority that supervised the safety of the Venetian Lagoon and the entire related infrastructure. Where circumstances dictated, aerobic treatment plants were to be installed and this meant the adoption of wastewater treatment technologies such as:

- MBR plants using membranes in wastewater treatment; and
- SBR plants using five stages of treatment.

The choice of a decentralised system follows the general and most up-to-date trends in terms of wastewater treatment using advanced and non-invasive technologies that support the delicate environment of the Venetian Lagoon.

In the historical city centre there are approximately 150 small treatment plants, a number are located within hotels. Some of these treatment plants are owned by the Municipality of Venice, where they are managed by VERITAS, a public company responsible for several environmental and public services, such as integrated water recycling and waste collection and disposal. In the historical city centre the 150 (approximate) treatment plants operate separately as there is no centralised system.

The Municipality of Venice owns 24 treatment plants, which treat only civil wastewater and are located all around the city and on the main islands of Burano, Murano and Sant'Erasmo. Most of the plants were acquired by the Municipality as part of a restructuring process and include blocks of flats for government housing as well as schools. These wastewater treatment plants, introduced as a result of Law 206/95, are independently operated and maintained.

Plants	Location	Technology	Person
Agostiniane	Murano	SBR	100
Fra' Mauro	Murano	SBR	800
San Donato	Murano	Activated Sludge	500
Chiovere	Cannaregio	SBR	960
San Marco	Cannaregio	MBR	870
Scuola S. Girolamo	Cannaregio	MBR	900
Area Saffa	Cannaregio	MBR	605
Ex-pastificio Zaggia	Giudecca	MBR	250
Giudecca 95	Giudecca	MBR	900
Scuola Duca d'Aosta	Giudecca	SBR	120
Area Dreher	Giudecca	MBR	100
Area Trevisan	Giudecca	MBR	310
Sacca Fisola	Sacca Fisola	MBR	1800
Area Fregnan	Sacca Fisola	MBR	320
Scoula Renier Michiel	Dorsoduro	SBR	120
Ufici Comunali Manin	San Marco	SBR	105
Mercato Rialto	Rialto	SBR	160
Scuola Morosini Pal.Carminati	S. Croce	MBR	160
Scuola Morosini Pal. Priuli	S. Croce	SBR	105
Ex-infermeria S. Anna	Castello	SBR	300
S.M. Ausiliatrice	Castello	SBR	170
S.Erasmo	S. Erasmo	MBR	4000
Isola Nuova Tronchetto	Tronchetto	MBR	1955
Mazzorbo	Mazzorbo	MBR	950

Public Aerobic Plants in the City of Venice [9]

The decision whether to build a SBR or a MBR plant is solely determined by the space available at the proposed location:

- SBRs operate using five steps:
  1. Filling
  2. Mixing
  3. Aerobic reaction
  4. Settling and drawing
  5. Discharge into the Venetian Lagoon.
- MBRs operate by combining the activated sludge treatment together with a separation of the biological sludge by an ultra-filtration membrane in order to produce a particle free effluent.

Twenty years after Italy's unique historical city of Venice was listed as a World Heritage Site it has become the centre of an equally unique development of modern technology in which a centralised control system manages the operation of 100 small decentralised wastewater treatment plants.

Destination: Sant'Erasmo Wastewater Treatment Plant

Location

Island of Sant'Erasmo, Venice, Italy, managed by the Venice Wastewater Authority

MBR treatment plant

The integrity of the landscape is maintained with treatment basins below ground

Objectives

The objective of the site visit was to observe the construction of the treatment plant, given its sensitive location within a community that has an extensive agricultural setting. The size, design and operation of the MBR plant, within the confines of the construction, were also a matter of interest to the Fellow.

Outcomes

The Plant has the capacity to service the equivalent of 4000 persons and collects wastewater from the islands of Sant'Erasmo and Burano by means of a vacuum sewerage system. The plant can treat up to 1000 cubic meters per day (cm/d) of wastewater and consists of an underground basin that handles the sedimentation, denitrification and nitrification treatment stages while the pressurised sidestream filtering system separates the solid and liquid phases. The filtering system consists of two parallel processing lines each constructed using 45 by 100 mm tubular modules with each module containing 37 tubular polymeric membranes. This provides a total of 450 square meters of filtration area. These two processing lines are configured with U bend components to form compact processing stacks to sit on a footprint of 5 square meters by 2.8 meters in height.

The plant has five modules of membranes, each module with seven membranes, and, with its treatment basins underground, blends without notice into the surrounding landscape. The plant treats wastewater with the potential to reuse it for irrigation considering the extensive agricultural activity of the island.

Destination: Hotel Danieli Wastewater Treatment Plant

Location

Venice, Italy, managed by the Venice Wastewater Authority

Objective

The objective of the site visit was to observe the MBR decentralised wastewater treatment plant in the most famous, and one of the earliest, hotels in Venice, the Hotel Danieli. Of particular interest was the location of the plant, its performance, monitoring and operation.

Hotel Danieli

MBR treatment plant

Outcomes

The Hotel Danieli is located in Calle delle Rasse overlooking the Riva degli Schiavoni. The owners were a noble Venetian family, the Dandolos. Palazzo Dandolo was one of the most splendid and richly decorated buildings in Venice and home to countless high society events. In the seventeenth century the Mocenigos and the Bernardos became the new owners and the building still belonged to these two families when the Venetian Republic fell in 1797. In October 1822 Giuseppe Dal Niel, a hotel keeper from Friuli, whose nickname was Danieli, rented the second floor of the Palazzo Dandolo from the Bernardo family turning it into a hotel. Between 1946 and 1948 the last structural works were completed leaving the Hotel Danieli as it appears today.

On the 31st May 1995 a special law, law 206/95, was introduced by the Venice Water Authority, which set out the introduction of urgent measures required for the upgrade of wastewater disposal systems and sanitation facilities that discharged into the Venetian Lagoon. The law, which outlined the installation of treatment plants, covered both private individuals and public companies.

The initial configuration of the Hotel Danieli treatment plant was based on SBR technology. This configuration was upgraded to MBR technology in 2003. The basis for the upgrade was to:

- Increase the treated flow from 170 cm/d to 240 cm/d; and
- Reuse part of the treated water as a reserve for the flushing of toilets.

The plant was configured in such a way as to have two sections each containing three different and independent membrane lines. Each membrane line was set in parallel and can be separately operated, thereby, allowing for maintenance or replacement of the remaining line or lines. Each membrane line consisted of seven membranes per core using an ultra-filtration-type membrane. The plant also consisted of two separate oxidation tanks that were fed independently.

In 2007 the MBR system was upgraded with the inclusion of a residual pressure recovery system with the aim to reduce the consumption of energy in the filtration process. That energy consumption was reduced from 4 kWhs per cubic meter down to 2 kWhs per cubic meter. Furthermore, the new design has located the membranes in series and also included a sludge recovery and reintegration pump between the four membrane modules. The oxidation tanks were also reconfigured to operate in series. An estimated saving of 40% was realised from this new design.[10]

In 2010 the MBR system was upgraded with the inclusion of sprinklers into the oxidation tanks that are activated by the residual pressure from the membranes. The aim was to reduce the energy consumption by reducing the operation time of the blowers.

The ultra-filtration section of the system currently comprises four modules that are fed in parallel with the first module containing 11 membranes. The second and third modules contain 12 membranes with the final module containing seven membranes, a total of 42 membranes. The membranes are housed in inox steel vessels. The porosity of the membranes is 1.0 micrometer (um), which allowed excellent biomass separation and flow disinfection.

The Hotel Danieli uses a tele-control system. The main function of the tele-control system is to provide the uninterrupted administration of the purification plant and management of the alarm and surveillance procedures by remote control. The system has the capability to process all the data gathered in the personal computer (PC). The tele-control system is essential in order to maintain a high level of dependability and control over the treated wastewater that is discharged into the Venetian Lagoon.

The Venice Water Authority uses the same tele-control system to manage the effective operation of wastewater treatment plants in Venice and for accurate up-to-date monitoring of the plants' components such as pumps, valves and levels.

The recorded data is stored and processed to calculate the ability of each plant to operate within the parameters required to produce the high quality, treated wastewater that is discharged into the Venetian Lagoon.

The tele-control software displays the layout of the plant and enables the user to interact with the remote station of the wastewater treatment plant by means of a typical Windows-based graphic interface. The user is able to set the operation, the alarm limits and all the functions to enable the optimal running of the plant.

Destination: Hilton Molino Stucky Venice

Location

Venice, Italy, treatment plant managed by the Venice Wastewater Authority

Hilton Molino Stucky Venice

Objectives

The objective of the visit was to observe the MBR decentralised wastewater system in the Hilton Molino Stucky Venice. To gain a real understanding of how the plant fitted into the existing building's construction, the plant's capability and function were also objectives of the visit.

Outcomes

The Hilton Molino Stucky Venice, an ancient mill, is an imposing red brick building that dates back to the nineteenth century. It has been recently renovated and converted into a residential hotel and is a popular tourist destination. It is located on Giudecca Island. Its MBR plant has two different membrane lines that can be activated independently.

Each line has six stages of nine membrane modules where the amount of water treated is approximately 670 cm/d. The modules are fitted with A37 membranes, which are able to reach twice the flow range of the type installed in the Hotel Danieli.

Left: MBR treatment plant

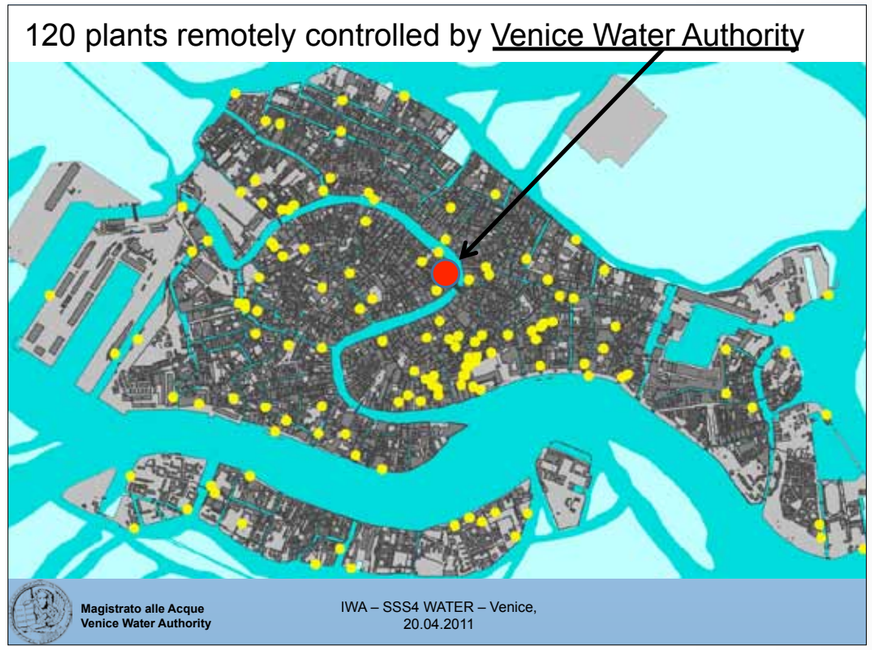
The ultra-filtration section has the patented in-series configuration to save energy. The plant is equipped with an innovative and patented vacuum wastewater piping system and the treatment basins are below ground.

Destination: Venice Water Authority

Location

Venice, Italy, remote control system that monitors decentralised wastewater treatment plants in Venice

The Venice Water Authority near the Rialto Bridge



Plan of Venice with the Venice Water Authority and treatment plants under remote control. Plan is courtesy of the Venice Water Authority.

An Aerial view of Venice

Objective

The objective was to observe the remote control system at the headquarters of the Venice Water Authority; this system monitors in real time the reliability and efficiency of the decentralised wastewater treatment plants in Venice.

Outcomes

The Venice Water Authority, which is located near the Rialto Bridge, has developed a remote control system that allows the control in real time of the state of operation of 120 decentralised wastewater plants situated throughout the historical town of Venice and the islands in the Venetian Lagoon.

Electrical, analogical and digital signals from the equipment and instrumentation of the plant, including pumps, valves, mixers, air blowers, level alarms, membrane pressure, dissolved oxygen and turbidity sensors, are monitored and transmitted by a Global System for Mobile Communication (GSM) network to the headquarters of the Venice Water Authority. There, it is possible to monitor in real time the performance of each plant. Each plant is represented with its specific layout, which includes alarm indicators, on and off control buttons and digital readings.

With the remote control system it is possible to monitor in real time the performance of each plant and to promptly identify the reasons for poor performance. Furthermore, it is possible to make statistical evaluations of the running of each plant in order to verify if the maintenance procedures are adequate and effective.

Destination: Treviso Wastewater Treatment Plant

Location

Treviso, Italy.

Contacts

Treviso Wastewater Treatment Plant visit conducted by Professor Paolo Pavan, Professor of Chemical Engineering, University of Venice, and Francesco Fatone, Assistant Professor, Department of Biotechnology, University of Verona.

Francesco Fatone, Assistant Professor, Department of Biotechnology, University of Verona

The Fellow, Paul Gray, at the research section of the Treviso Wastewater Treatment Plant

Objective

The objective of the site visit was to study the wastewater treatment process and the inventive approach to problem solving and improvement measures of the plant's production.

Outcomes

The Treviso Wastewater Treatment Plant is managed by the Municipality of Treviso and is situated in an environmentally sensitive area. A training and research facility on the site is operated quite separately but in co-operation with the plant's management team. Research and testing as well as the monitoring of the plant are conducted by Professor Paolo Pavan of the University of Venice, Assistant Professor Francesco Fatone of the University of Verona and Assistant Professor David Balzonella also from the University of Verona.

Included on the site are classrooms, where lectures are delivered to Chemical Engineering students by Assistant Professor Francesco Fatone and Assistant Professor David Balzonella, and a laboratory, where experiments and research are carried out. In addition to the laboratory, there are various purpose-built, scaled-down treatment plants where research is conducted over an extended period and the findings then presented at conferences and seminars.

The Treviso Wastewater Treatment Plant has adopted an innovative approach to the treatment of municipal organic solid waste. The process involves the shredding of the bio-waste followed by the removal of metals. The product is then put through a drum sieve for the removal of plastics. The pre-treated material then undergoes a wet refine system where both heavy and light inert materials are removed. After wet refining the organic residual matter is mixed with waste-activated sludge and fed to the anaerobic digester. As a result of this process the bio-gas production is measured at 150 cm/d of which 66% is methane.[11] The methane, an energy source, is used in the drying process of the sludge that is produced by the treatment plant. This sludge is then transformed into compost that is used by local farmers.

Generally the Anaerobic Digestion Reactor is operated at mesophilic conditions. However, trials were conducted operating the digester at thermophilic conditions, which produced an increased bio-gas yield of 30% demonstrating a further economical benefit.[12]

Destination: San Giorgio di Nogaro

Location

Italy

Contacts

San Giorgio di Nogaro Wastewater Treatment Plant visit conducted by Assistant Professor David Bolzonella and Massimiliano Panigutti, Plant Manager.

Objective

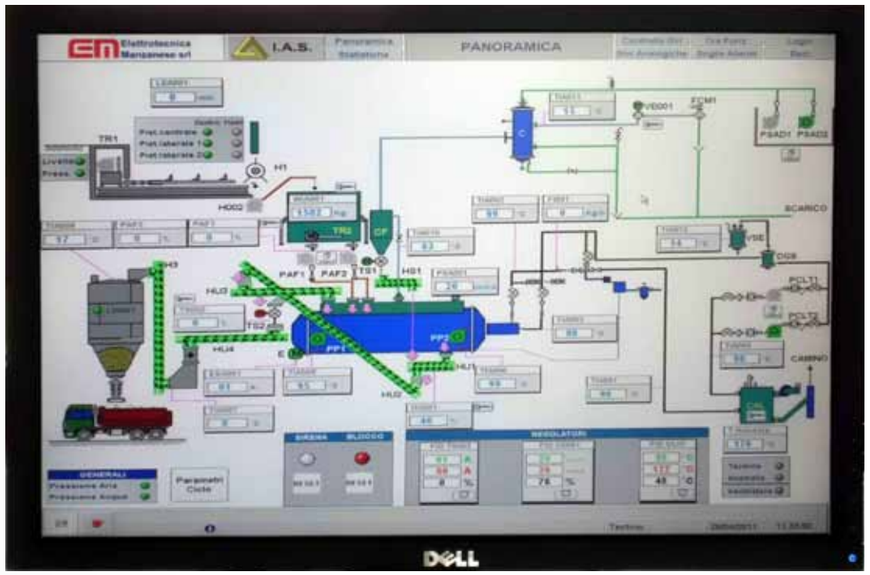
The objective of the visit was to observe the remote control management system of the wastewater treatment plant.

Outcomes

The Fellow observed that the San Giorgio di Nogaro Wastewater Treatment Plant was monitored and operated totally by remote control. The process control and remote control software systems were designed and patented by Professor Paolo Battistoni of Polytechnic University of Marche.

Professor Battistoni found that when an automatic control device was applied to the management of an alternate oxic–anoxic process in a small wastewater treatment plant (servicing the equivalent population of 700 people) the following was observed: the control system enabled the optimal time length of the aerobic and anoxic phases to be determined by analysing the dissolved oxygen and the oxidation-reduction potential data.

Schematic of the treatment plant in the control office



Computer generated remote control program

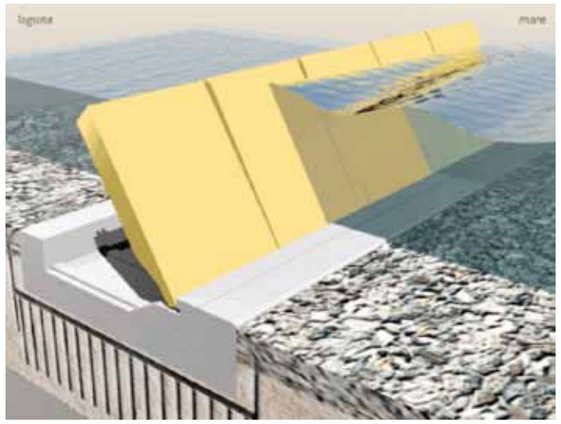
Moreover, a time set point was also introduced to establish the maximum length for the two phases. Results showed high performances in biological nitrogen removal and a reliable control of the treatment process during wet weather events. In comparison with extended aeration plants of similar size, lower energy consumption was observed. The automatic control device was a reliable system that gave a good performance in small wastewater treatment plants with low investment and managing costs.

The computer operated software programs were set up in the San Giorgio di Nogaro treatment plant's main control room and are operated solely by the plant's manager, Massimiliano Panigutti. The program is able to monitor in real time the operation of the plant and control that operation from the one computer terminal. When an irregularity in the plant's operation is observed from the computer terminal an adjustment is made remotely and automatically from that terminal. The use of the system has realised an overall saving in energy of 30% over a twelve-month period.[13] With the software and probes for the remote control and management system costing 90,000 Euros the payback period was estimated to be three years.

Destination: The MOSE Project

Description

The Modulo Sperimentale Elettromeccanico [Experimental Electromechanical Module] Project (MOSE Project) is managed by Venice Water Authority through the Consorzio Venezia Nuova



A model of the MOSE Project gates

The three inlets where the MOSE Project gates will be positioned

Objective

The objective of the visit was to gain an understanding of the enormity of the project and the measures that the Ministry of Infrastructure and Transport and the Venice Water Authority have undertaken to protect Venice and the Venetian Lagoon ecosystem from the Adriatic Sea.

Outcomes

Venice is subject to flooding due to the Acqua Alta, which is the term commonly used in Veneto for the exceptional tide peaks that occur periodically in the northern Adriatic Sea. The peaks, which reach their maximum as they enter the Venetian Lagoon via three inlets, cause partial flooding of Venice and Chioggia, a coastal town in the province of Venice. The phenomenon occurs mainly between autumn and spring when the astronomical tides are reinforced by the prevailing seasonal winds.

As a result of this phenomenon 20% of Venice's wastewater is discharged directly into the Venetian Lagoon.[14] This includes MBRs being switched to bypass to avoid the ingress of salt water into the system. One of the benefits of the MOSE Project will be to greatly reduce the incidence of wastewater overflow into the Venetian Lagoon.

The MOSE Project is a system of mobile barriers that will protect Venice and the Venetian Lagoon from the frequent and intense flooding. The MOSE Project is designed to cope with these exceptional events, which have had devastating effects for the city of Venice and its ecosystem, and more frequent flooding producing constant inconvenience and progressive degradation of buildings and the environment. One of the most important hydraulic engineering projects ever realised, the barriers consist of a series of gates that are normally not visible as they are resting on the seabed in the inlets. If danger threatens the gates will be raised, shutting the Venetian Lagoon off from the sea.

Normally the barriers/gates will be full of water and rest on the seabed. When flooding is forecast due to high tide prediction by the Venice Water and Tides Center Institution compressed air will be pumped into the gates emptying them of water causing them to rise and emerge blocking the tide as it enters the Venetian Lagoon. When the tide drops the gates will be filled with water again and return to their housing on the seabed. Thanks to the designed operational flexibility the MOSE Project will be able to cope with floods in various ways: by simultaneously closing all three inlets during an exceptional event or by closing one inlet at a time or partially closing each inlet during medium to high tides. There will be no functional constraints to the operation of the system.

The MOSE Project will provide protection from tides up to three meters high and will continue to be effective in the event of a rise in sea level in the future.

The MOSE Project is the last and most important element in the plan of measures implemented by the Venice Water Authority through the Consorzio Venezia Nuova to safeguard the Venetian Lagoon area.

Concluding Remarks

The Fellowship program has been instrumental in facilitating the attainment of knowledge in relation to the goals and aspirations that were the focus of the international experience.

Knowledge Transfer: Applying the Outcomes

The Fellowship has given Gray the opportunity to witness first hand the technological advances in the management of decentralised wastewater treatment plants in and around the city of Venice. The Fellow was able to observe the real-time monitoring of each plant by a centralised system developed by the Venice Water Authority to control the efficiency of each of these decentralised plants.

The installation of a MBR treatment plant into one of Venice's most famous landmarks, the Hotel Danieli, demonstrated the ability to upgrade the hotel's wastewater treatment system to meet the guidelines established to protect the water quality of the Venetian Lagoon.

The advantages of this technology has been twofold: one, in meeting the guidelines of the quality of the effluent and, two, in the reuse of the wastewater for flushing purposes on a decentralised commercial scale.

The opportunity exists for government at the state and local level to further embrace the conservation of our most precious commodity, our fresh water supply. Our water conservation can be extended by the introduction of MBR decentralised wastewater treatment plants for commercial and domestic premises where the treated water can be reused for serving flushing devises and for irrigation purposes. These systems can be for new as well as existing developments. Coupled with the wastewater treatment plant is the introduction of a remote control system that can both monitor and control in real time the operation of these treatment plants adding an economic saving to the whole process. The monitoring of any system and the implementation of remedial measures and maintenance as required is paramount to its successful operation.

Industry associations and industry in general will need to embrace and promote new technologies with a view to the conservation of our water supply and the remote monitoring and control of these systems. The system in its entirety will need to be adopted and promoted.

This information will be disseminated at the next meeting of the Plumbing Training Moderation Group of Australia and the Victorian Plumbing Training Managers Committee in mid-October 2011. The aim is to create an awareness of and to promote decentralised wastewater treatment plants with the emphasis on the remote monitoring and control software program. The Plumbing Industry Commission's Manager of Practitioner Development attends the meetings of these groups on a regular basis.

The National Plumbing and Services Training Advisory Group will also be included in the information dissemination process. This group covers plumbing training on a National basis and is readily contactable via their interactive website. This report will be made available to members of the National Plumbing and Services Training Advisory Group via their interactive website, this will increase the dissemination of the knowledge gained by the Fellow.

Presentations will be delivered to Certificate III students as well as industry representatives currently undertaking Certificate IV. Up-to-date information will also be included in resources CPCPDR 2002A Install Domestic Treatment Plants, CPCPDR 2003A Maintain Effluent Disinfection Systems & CPCPDR 3003A Install Onsite Disposal Systems.

Recommendations

Government

- Adopt decentralised wastewater treatment plants into the design and development of future government buildings with the reuse of that wastewater for flushing purposes. Include in these developments a centralised remote control and monitoring system for these plants.
- Investigate the retrofitting of decentralised wastewater treatment plants into existing government buildings that are to be upgraded or refurbished.

Industry

- Through the appropriate industry association establish conformity and standards relating to the installation and operation of remote control and monitoring of wastewater treatment plants.

Education and Training

- The Fellow will be available to assist education institutes in the enhancement of training resources in wastewater treatment and facilitate the introduction of remote system monitoring and control information.
- The Fellow intends to pursue the offer of a collaborative approach to training and research that was extended by Associate Professor Francesco Fatone of the University of Verona. The remote monitoring and control of decentralised wastewater treatment plants requires further study and exploration for its suitability and adaptation into the Australian wastewater treatment process.

ISS Institute

- During the Fellow's visit to the Treviso wastewater treatment plant, Francesco Fatone, Assistant Professor, Department of Biotechnology of the University of Verona expressed a firm desire to form a collaborative approach to research and training in the field of wastewater treatment. This is an avenue that the Fellow recommends should be pursued and is an opportunity that cannot afford to be neglected.

References

Endnotes

[1] *Sustainable Policies for a Dynamic Future*, Carolynne Bourne AM, ISS Institute 2007.

[2] Ibid.

[3] Wikipedia page was last modified on 31 August 2011, http://en.wikipedia.org/wiki/MOSE_Project, viewed September 2011.

[4] *Directory of Opportunities. Specialised Courses with Italy. Part 1: Veneto Region*, ISS Institute, 1991.

[5] World Commission On Environment and Development 1987, *Our Common Future*, Oxford University Press, Oxford, United Kingdom.

[6] Skills Australia's *Australian Workforce Futures: A National Workforce Development Strategy 2010*, pp. 1-2. http://www.skillsaustralia.gov.au/PDFs_RTFs/WWF_strategy.pdf

[7] Information provided through discussions with Professor Paolo Battisoni, Polytechnic University of Marche.

[8] Massimiliano Panigutti, Manager, San Giorgio Wastewater Treatment Plant.

[9] Carrer, S 2011, *Technical tour n.1, The MBR treatment plant of Hotel Danieli, IWA Venice, Italy 18-22 April*, PowerPoint presentation.

[10] Rizzetto, R & Carrer, S 2011, *Management of Decentralized Waste Water Treatment Plants in Venice. Analysis of Costs and Efficiency*, SSS 4 WATER, Venice, Italy, course notes.

[11] Information provided through correspondence with David Bolzonella, Assistant Professor, Department of Biotechnology, University of Verona.

[12] David Bolzonella Department of Science and Technology University of Verona Italy. Water & Science Technology Volume 53 No.8 pp 203–211.

[13] Information provided through discussions with Massimiliano Panigutti, Plant Manager, San Giorgio di Nogaro Wastewater Treatment Plant and David Bolzonella Assistant Professor, Department of Biotechnology, University of Verona.

[14] Information provided through notes taken by Fellow during a site visit to the MOSE Project.

Conference Material

- Rizzetto, R & Carrer, S 2011, *Management of Decentralized Waste Water Treatment Plants in Venice. Analysis of Costs and Efficiency*, SSS 4 WATER, Venice, Italy.
- Ministry of Infrastructure and Transport, Venice Water Authority, 2010, *The MOSE Construction Sites*, Consorzio Venezia Nuova Communications Office, Venice, Italy.
- Tromellini, E 2011, *The Decentralized Wastewater Treatment System of the City of Venice Leads to the Improvement of Water Quality in its Canals*, SSS 4 WATER, Venice, Italy.
- Carrer, S; Croci, F; Volpato, E & Ferrari, G 2011, *MBR and SBR Decentralized Treatment Plants for the City of Venice. Reliability and Efficiency Analysed Through a Remote Control System*, SSS 4 WATER, Venice, Italy.

Websites

- Venice Water Authority, Venice, Italy, www.salve.it/uk/default.htm, viewed May 2011.
- IWA, SSS 4 WATER events page, Venice, Italy, http://www.incaweb.org/events/SSS4/, viewed September 2011