018530 - SWITCH

Sustainable Water Management in the City of the Future

Integrated Project
Global Change and Ecosystems

D5.3.12: 6 PhD and 18 MSc theses on the theme of this work package

Overview of PhD and MSc research within workpackage 5.3

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

SWITCH WP 5.3 - Maximising the Use of Natural Systems in all Aspects of the Municipal Water Cycle

D5.3.12 - 6 PhD and 18 MSc theses on the theme of this work package

The research under this work package aimed at maximizing the exploitation of natural systems and processes for the effective management of municipal water resources, of water supply and sanitation services, and of the municipal water cycle as a whole. The main technologies studied were (1) Bank Filtration and Artificial Recharge and Recovery (pre-)treatment systems for drinking water, (2) Constructed Wetlands and Waste Stabilization Ponds for treatment of waste water and storm water with subsequent recovery of water and nutrients and (3) Hyporheic Zone Treatment and in-stream remediation as options to stimulate the self-purification capacities of water bodies.

MSc and PhD research within WP 5.3 was related to 4 main tasks:
- Task 1: Inventory / literature review of natural systems and processes for urban water management
- Task 2: Natural systems for drinking water treatment
- Task 3: Natural systems and processes for wastewater and stormwater treatment and reuse
- Task 4: Natural systems for the stimulation of water retention and self purification capacity of water resources

In the table on the next pages an overview is given of completed and ongoing PhD and MSc research per task. Subsequently, abstracts of all theses are included in this document. The theses itself can be download from the SWITCH database.

Table of MSc and PhD research in SWITCH WP 5.3 - final overview compiled in March 2011

Task 2 - Natural systems for drinking water treatment		
Multiple Objective Treatment Aspects of Bank Filtration	A. Maeng	IHE - PhD
Organic matter characterisation and EDCs removal during riverbank filtration	M.O. Ibrahim	IHE - MSc
EDC removal during river bank filtration	S. Devkota	IHE - MSc
Impact of Biodegradability of Natural Organic Matter and Redox Conditions on Removal of Pharmaceutically Active Compounds during Riverbank Filtration	C. Abel	IHE - MSc
QSAR-Based Model for Assessment and Prediction of Organic Micropollutants Removal during bank filtration	H.W. Simarmata	IHE - MSc
Task 3 - Natural systems for wastewater and stormwater treatment		
Effect of Algal Biofilm and Operational Conditions on Nitrogen Removal in Wastewater Stabilization Ponds	M. Babu	IHE - PhD
Development of a Technology Selection Model for Pollution Prevention and Control in the Municipal Water Cycle.	A. Galvis	IHE - PhD UNIVALLE - PhD
Greenhouse Gas Emissions from Eco-technological Wastewater Treatment Systems	J.P. Silva	IHE - PhD UNIVALLE - PhD
Possibilities for Recycling Domestic Wastewater with Vertical Flow Constructed Wetlands	R. Shrestha	IHE - MSc
Grey water treatment using natural wetlands	A. Muzola	KNUST - MSc
Grey water treatment using constructed wetland at KNUST in Kumasi	P. Niyonzima	KNUST - MSc
Water quality enhancement in Sloterbinnenpolder (Amsterdam, The Netherlands) by adopting ecological engineering approaches	A.M.M. Ali	IHE - MSc
Effect of some environmental factors on nitrification in algae-bacterial biofilm	T. Munezvenyu	IHE - MSc
The use of natural systems for the treatment of greywater: A case study of Kpeshie lagoon	M. Ansah	KNUST - MSc
Faecal sludge management: the case of Madina	P. Antwi-Agyei	KNUST - MSc
Laboratory study on the emissions of N2O, CH4 and CO2 from activated sludge	A.F. Saeed	IHE - MSc
Modelling the ecological impact of wastewaters on the Cauca River (Colombia)	J.E. Holguin	UGhent - MSc UNIVALLE - MSc
Estimacion de gases de efecto invernadero en humedales construidos de flujo subsuperficial horizontal - Estimation of greenhouse gas emissions from horizontal subsurface flow constructed wetlands	A. Valverde Solis	UNIVALLE - MSc

Tratamiento de aguas residuales municipales en el Valle de Cauca - Treatment of municipal wastewater in Valle del Cauca	C.L. Suarez Marmolejo	UNIVALLE - MSc
Selección de Tecnología para la Recolección y Transporte de Aguas Lluvias y Aguas Residuales en Áreas Urbanas - Technology selection for the collection and transport of rainwater and wastewater in urban areas	F. Montaña Duque	UNIVALLE - MSc
Cámaras estáticas para la estimación de gases de efecto invernadero en lagunas de estabilización para el tratamiento de aguas residuales domésticas	A.P. Lasso Palacios	UNIVALLE - MSc
Minimización y prevención como estrategia para el control de la contaminación por aguas residuales municipales en la zona de expansión de Cali - Minimization and prevention as strategies to control contamination by municipal wastewater in the expansion zone of Cali	D.A. Zambrano	UNIVALLE - MSc
Potencial de reuso de agua residual doméstica como estrategia para el control de la contaminación por agua residual en el valle geográfico del río Cauca - Potential of reusing domestic wastewater as a strategy to control contamination by wastewater in the geographical valley of the Cauca river	M. F. Jaramillo	UNIVALLE - MSc
Analysis of the impact of diffuse pollution sources related to the land use and management practices in the production of sediment in the Palo river basin	E. Cifuentes	UNIVALLE - MSc
Proposal for applying sustainable urban drainage systems on the lower basin of the Cañaveralejo river	E.A. Jiménez Ríos	UNIVALLE - MSc
Task 4 - Natural systems for the stimulation of water retention and self purification capacity of water resources		
Influences of the application of the three-year dose of sewage sludge on the biomass of the different type of the energetic willow	R. Kolasa	ULodz - MSc
The use of phytotechnology in the utilization of the sewage sludge and compost on the Waste Water Treatment Plant in the City of Lodz.	M. Klonowski	ULodz - MSc
Application of nucleic acids as the indicator in analysis of ecohydrological processes	M. Godowska	ULodz - MSc
The influence of water flow on sedimentation in dam reservoirs cascade on Sokolowka	M. Przybylak	ULodz - MSc
Ecosystem biotechnologies – modification of ecosystem properties as a method of protection and renaturalization of water resources, the example of Sokolovka river revitalization project	L. Nowacki	ULodz - MSc
Identification of anthropogenic contamination in the Sokolowka river catchment	M. Cichoń	ULodz - MSc

Vermicomposting of sewage sludge as a method to obtain increase of biomass of the energetic willow on the protected zone of the Wastewater Treatment Plant (WWTP) in Lodz	K. Tomczyk	ULodz - MSc
Defining relationship between plant cover and ground waters as a key for identification of rehabilitation hot-spots in an urban river valley	M. Olejniczak	ULodz - MSc
Energetic willow as an instrument for sustainable development implementation	B. Wojtyra	ULodz - MSc
Hydromorphological evaluation of water courses and river bed retention of streams in Sokolowka catchment	P. Kożuchowski	ULodz - MSc
Land use and impermeability of ground in urban areas (the Sokolowka catchment case study	A. Durys	ULodz - MSc
Water supply and sewage disposal in the Sokolowka catchment.	P. Kujawski	ULodz - MSc
Benthic diatoms used to assessment of water quality of the Sokołówka River	K. Nowak	ULodz - MSc
Benthic diatoms of reservoirs on the Sokolowka River	P. Nowicka	ULodz - MSc
Drivers and pressures of city water resources – developing risk-based decision support system for implementation of Ecohydrology approach.	R. Włodarczyk	ULodz - MSc
The city gardens as a potential component of the Blue-Green Network – influence of people's attitudes on quality of environment.	M. Zasępa	ULodz - MSc
Assessing vertical water flux between groundwater and surface water at the River Tame Hyporheic Zone SWITCH Test Site using temperature time series.	M.B. Hendrie	UBHam - MSc
Hydraulic controls on water quality variations: The River Tame Hyporheic zone SWITCH urban test site	S. Shepherd	UBHam - MSc
HYPHOREIC ZONE HYDRAULIC TESTING: RIVER TAME, BIRMINGHAM	J.L. Whelan	UBHam - MSc
ASSESSMENT OF GROUNDWATER-SURFACE WATER MIXING ZONE TRANSIENTS: BIRMINGHAM-RIVER TAME STUDY	D.J. Conran	UBHam - MSc
Design for the Hyporheic Zone Dipole Setup	C. Lydon	UBHam - MSc
OPTYMALIZACJA WYKORZYSTANIA OSADU ŚCIEKOWEGO DO PRODUKCJI BIOENERGII NA PODSTAWIE WIELKOSKALOWYCH EKSPERYMENTÓW TERENOWYCH ORAZ MODELU MATEMATYCZNEGO	A. DROBNIEWSKA	ULodz - PhD
ANALIZA PORÓWNAWCZA ZAWARTOŚCI DIOKSYN I ZWIĄZKÓW DIOKSYNOPODOBNYCH W ZBIORNIKACH ZAPOROWYCH O RÓŻNYCH FORMACH ANTROPOPRESJI	M. URBANIAK	ULodz - PhD

S.K. Maeng (2010). Multiple Objective Treatment Aspects of Bank Filtration. PhD Thesis, UNESCO-IHE.

The need for safe and good quality drinking water is growing rapidly worldwide, especially with increased urbanization and population growth. However, increasing pollution of surface waters, often by wastewater effluents, has made water treatment more difficult and expensive. Furthermore, most water resources, especially surface waters in industrialized and urban areas in developing countries, are quickly deteriorating as a result of uncontrolled waste discharges into receiving waters, which may also serve as drinking water sources. Consequently, this has led to the occurrence of potentially harmful organic micropollutants (OMPs) in drinking water treatment systems and ultimately in drinking water.

Bank filtration (BF) is a natural water treatment process which induces surface water to flow in response to a hydraulic gradient through sediment and into a vertical or horizontal well. It is a relatively cost-effective and robust technology. From a historical perspective, BF is first mentioned in the bible. In chapter 7 phrase 24 in Exodos, "all the Egyptians had to dig in the neighbourhood of the river for drinking water, since they could not drink the river water." BF has been recognized as a proven method for drinking water treatment in Europe. But these facilities have all been based on local experiences and thus far, there are no tools or a methodology that would help to transfer these experiences or the design and operation of a system from one place to another. Understanding the fate of effluent organic matter (EfOM) and natural organic matter (NOM) through BF is essential to assess the impact of wastewater effluent on the post treatment requirements of bank filtrates. Furthermore, their fate during drinking water treatment can significantly determine the process design.

Laboratory-scale batch and soil column experiments as well as analysis of the data from full-scale bank filtration and artificial recharge sites were conducted to obtain insight into the effect of source water quality (especially organic matter characteristics) and process conditions on the removal of organic micropollutants during soil passage. Wastewater effluent-impacted surface water and surface water were used as source waters in experiments with soil columns. Results showed the preferential removal of non-humic substances (i.e., biopolymers) from wastewater effluent-impacted surface water. The bulk organic matter characteristics of wastewater effluent-impacted surface water and surface water were similar after 5 m soil passage in laboratory column experiment. Humic-like organic matter in surface water and wastewater effluent- impacted surface water persisted through the soil passage. More than 50% of dissolved organic carbon (DOC) removal with significant reduction of dissolved oxygen (DO) was observed in the top 50 cm of the soil columns for both surface water and wastewater effluent-impacted surface water. This was due to biodegradation by soil biomass which was determined by adenosine triphosphate (ATP) concentrations and heterotrophic plate counts. Good correlation of DOC removal with DO and biomass development was observed in the soil columns.

Managed aquifer recharge (MAR) systems such as BF have been recognized as a multiobjective (-contaminant) barrier to provide safe drinking water by attenuating endocrine disrupting compounds

(EDCs) and pharmaceutically active compounds (PhACs). In this thesis, the fate of selected EDCs and PhACs during soil passage was investigated. Firstly, estrogen compounds (i.e., EDCs) were tested to determine if these compounds can be attenuated during BF. Adsorption and biodegradation are the two important removal mechanisms for estrogen compounds (estrone, 17-estradiol and 17-ethinylestradiol), but adsorption exhibited to be the important removal mechanism. 17-estradiol and 17-ethinylestradiol were removed 99% and 96%, respectively, in batch experiment under oxic conditions. Biomass associated with sand and redox conditions did not show any significant effects on the removal of 17-estradiol. However, 17-ethinylestradiol removals varied from 64% to 87% in soil columns fed with different sources of water. Biodegradation appears to be more important in the removal of 17-ethinylestradiol. Estrogenic activity remaining under oxic conditions (13 ng estradiol-equivalents/L) was significantly lower than that of under anoxic conditions (97 ng estradiol-equivalents/L).

Secondly, batch studies were first conducted to investigate the removal of 13 selected PhACs from different water sources with respect to different sources of biodegradable organic matter. Column experiments were then performed to differentiate between biodegradation and sorption in the removal of these PhACs. Selected neutral PhACs (phenacetine, paracetamol and caffeine) and acidic PhACs (ibuprofen, fenoprofen, bezafibrate and naproxen) exhibited removal efficiencies of greater than 87% from different organic water matrices during batch studies (contact time: 60 days). In column studies, removal efficiencies of acidic PhACs (e.g., analgesics) decreased under biodegradable organic carbon-limited conditions. Removal efficiencies of selected acidic PhACs (ibuprofen, fenoprofen, bezafibrate, ketoprofen and naproxen) were less than 35% under abiotic conditions. These removals were attributed to sorption under abiotic conditions established by a biocide (20 mM of sodium azide), which suppressed microbial activity/biodegradation. However, under biotic conditions, removal efficiencies of these acidic PhACs compounds were greater than 78%, mainly attributed to biodegradation. Moreover, average removal efficiencies of hydrophilic (polar) neutral PhACs with low octanol/water partition coefficients (log Kow < 2) (paracetamol, pentoxifylline, phenacetine and caffeine) were low (< 12 %) under abiotic conditions. However, under biotic conditions, removal efficiencies of selected neutral PhACs were greater than 91%. In contrast, carbamazepine showed a persistent behavior under both batch and column studies. Overall, results of this study showed that biodegradation is an important mechanism for removing PhACs during soil passage.

This study also analyzed a comprehensive database of OMPs at BF and artificial recharge (AR) field sites located near Lake Tegel in Berlin (Germany). The focus of the study was on the derivation of correlations between the removal efficiencies of OMPs and key factors influencing the performance of BF and AR. At the BF site, shallow monitoring wells located close to the Lake Tegel source exhibited oxic conditions followed by prolonged anoxic conditions in deep monitoring wells and a production well. At the AR site, oxic conditions prevailed from the recharge pond along monitoring wells up to the production well. Long residence times of up to 4.5 months at the BF site reduced the temperature variation during soil passage between summer and winter. The temperature variations were greater at the AR site as a consequence of shorter residence times. Deep monitoring wells and the production well located at the BF site were under the influence of ambient groundwater and old bank filtrate (up to several years of age). Thus, it is important to account for mixing with native groundwater and other sources (e.g., old bank filtrate)

when estimating the performance of BF with respect to removal of OMPs. Principal component analysis (PCA) was used to investigate correlations between OMP removals and hydrogeochemical conditions with spatial and temporal parameters (e.g., well distance, residence time, and depth) from both sites. At the BF site, principal component-1 (PC1) embodied redox conditions (oxidation reduction potential and dissolved oxygen), and principal component-2 (PC2) embodied degradation potential (e.g., total organic carbon and dissolved organic carbon) and the calcium carbonate dissolution potential (Ca^{2+} and HCO_3^-). These two PCs explained a total variance of 55% at the BF site. At the AR site, PCA revealed redox conditions (PC1) and degradation potential with temperature (PC2) as principal components, which explained a total variance of 56%.

There is a need to develop assessment tools to help implement MAR as an effective barrier in attenuating different OMPs including PhACs and EDCs. In this study, guidelines were developed for different classes of OMPs, in which removal efficiencies of these compounds are determined as a function of travel times and distances. Guidelines are incorporated into Microsoft Excel spreadsheets and the water quality prediction tool was developed to estimate the removal of different classes of OMPs in MAR systems. Multiple linear regression analysis of data obtained from literature studies showed that travel (residence) time is one of the main parameters in estimating the performance of a MAR system for PhACs removal. Moreover, a quantitative structure activity relationship (QSAR) based model was proposed to predict OMP removals. The QSAR approach is especially useful for emerging compounds with little information about their fate during soil passage. Such an assessment framework for OMP removals is useful for adapting MAR as a multi-objective (-contaminant) barrier and understanding the fate of different classes of compounds during soil passage and the determination of post treatment requirements for MAR.

In general, this study showed that BF is an effective multiple objective barrier for removal of different contaminants present in surface water sources including organic micropollutants like PhACs and EDCs. The removal efficiencies of BF for these contaminants can be maximised by proper design of the recovery wells taking into consideration source water quality characteristics and local hydrogeological conditions.

M.O. Ibrahim (2007). Organic Matter Characterization and EDCs Removal during Riverbank Filtration. UNESCO-IHE thesis MWI 07.16.

Natural treatment system like river bankfiltration (RBF) is attractive for drinking water production because of its low cost, sustainability, performance, and relevance to both developed and developing countries. Its effectiveness has been proved in Europe and USA where it has been utilized for decades. Filtration, biodegradation, adsorption, and dilution are the main processes to produce significant improvements in raw water quality during RBF.

Detailed information on organic matter removal by RBF systems subjected to different processes and hydrogeological conditions is essential for rational design of RBF systems and to predict degree of purification provided by RBF at various sites. Therefore, as part of the ongoing effort, this study was focused on characterization of organic matter (OM) and removal of three endocrine disrupting compounds (EDCs) (Estrone (E1), 17β-Estradiol (E2), and Ethynlestradiol (EE2)) during RBF under different process conditions.

Laboratory based soil column and batch experiments were conducted to characterize OM and to study removal of EDCs during RBF. Investigation of the main process responsible for the removal was also carried out. Delft canal water (DCW) and secondary effluent (SE) from Hoek Van Holland wastewater treatment plant were used as an influent. Silica sand of size 0.8-1.25 mm was used as a filter media. Steroid estrogens were quantified using a biological technique called enzyme linked immunosorbent assay (ELISA). Solid phase extraction (SPE) was applied as a sample pre-treatment technique for ELISA.

A DOC removal of 13 and 20 % was found in 5 m long soil column with DCW and DCW mixed with SE (1:1) respectively at HLR of 1.25 m/d. The lower DOC removal from DCW was attributed to its lower BDOC content. Decreasing HLR to 0.625 m/d reduced the removal efficiency to 10 and 17 % for DCW and DCW mixed with SE respectively. A maximum achievable removal efficiency of 44 % from DCW and 53 % from the mixed sample were estimated at HLR 1.25 m/d. Batch studies showed better removal efficiency as compared to soil column at HLR of 1.25 m/d. A DOC removal of 20 and 24 % was achieved in batch studies with DCW and mixed sample respectively. It was also found that organic matter decomposition under aerobic condition was faster as compared to anoxic condition. A good positive correlation was observed between organic matter removal, biomass development and oxygen consumption. Batch studies showed removal of EDCs ranging from 47 to 98 % with ELISA recovery from 45 to 118 %. Bioadsorption was identified as the main removal mechanism for steroid estrogens. The overall EDC removal from DCW mixed with SE under aerobic condition was 96, 93 and 79 % for E1, E2 and EE2 respectively. Characterization of organic matter in DCW and SE revealed that DCW has more DOC with less BDOC component as compared to SE. SUVA values of both DCW and SE indicated the presence of a mixture of high and low molecular weight, humic and non humic, and hydrophobic and hydrophilic OM in the samples. However, relatively DCW is more humic and hydrophobic than SE.

S. Devkota (2008) Endocrine Disrupting Compounds Removal During Riverbank Filtration. UNESCO-IHE MSc Thesis MWI 08.28.

Riverbank filtration (RBF) is the natural process of water treatment. It is a low cost and robust technology and relevant to both developed and developing countries. It is well known technology in USA and Europe where it has been utilized for decades. In RBF process filtration, biodegradation, adsorption and dilution are the main mechanisms.

Nowadays, large varieties of Endocrine Disrupting Compounds (EDCs) are present in raw water resources where the raw water is strongly influenced by wastewater effluent. Among many EDCs, estrogens such as estrone (E1), 17β-estradiol (E2) and 17α- ethinylestradiol (EE2) showed the most estrogenic activity, than alkylphenols (APs) and their ethoxylates (APEOs). RBF is a promising technology for pre-treatment of raw water prior to conventional water treatment which reduces the cost of chemicals. Therefore, this study was focused on analysis of estrogen removal during RBF. Better understanding of EDCs removal helps in rational design of RBF systems.

Laboratory-scale batch and soil column experiments were conducted to study the removal of estrogens during RBF. Mixture of Delft canal water (DCW) and secondary effluent (SE) in 1:1 ratio was used as influent. Silica sand of size 0.8-1.25 mm diameter was used as a filter media. Mainly estrogens compounds were quantified by using enzyme linked immunosorbent assay (ELISA). Solid phase extraction (SPE) was applied for sample pre-treatment. Similarly, fluorescence excitation-emission matrix (FEEM) was used for kinetic fate study.

Abiotic batch experiment was conducted to determine the optimum concentration of sodium azide (NaN_3) to inactivate the micro-organisms and it was found that 2 mM NaN_3 was appropriate without any interference with ripened layer of the sand. Batch adsorption experiments were conducted to establish isotherms of E2 and EE2. It was found that, in ripened sand removal of E2 was 99.9 % isotherms was not obtained but in the case of EE2 adsorption capacity and intensity was 0.28 µg/g and 0.67. Similarly, in clean sand adsorption capacity of E2 and EE2 was 0.20 µg/g and 0.21 µg/g and corresponding intensity was 0.95 and 0.63. Batch study for determination of factors affecting estrogen removal showed that the maximum removal was 99.9 % and 95.8 % for E2 and EE2 respectively. Adsorption and biodegradation played the main role of removal. Biotic and oxic conditions and organic material content in soil aquifer were main favorable factors for removal.

EE2 removal in soil column with tap water was 25.9 % to 64.1 %, with mixture of DCW & SE (abiotic) was 46.0 % to 66.7 % and with mixture of DCW & SE was 49.0 % to 87.0 % with variation in flow rate was 0.4 ± 0.15 m/d. Removal efficiency depended on flow rate, organic material and microbial activity.

C.D.T. Abel (2009). Impact of Biodegradability of Natural Organic Matter and Redox Conditions on Removal of Pharmaceutically Active Compounds during Riverbank Filtration. UNESCO-IHE MSc Thesis MWI 09.30.

Riverbank filtration (RBF) is a low cost, robust and sustainable natural filtration process which has been in use for drinking water production for more than a century. During RBF, water filtration is achieved by inducing hydraulic gradient to pass river water through riverbank sediments and recovered from adjacent wells field after mixing with native groundwater. During this soil passage, raw water quality is improved through physical, biological and chemical processes. However, some contaminants in surface water are cleaved and attenuated while some are not eliminated; instead they leach through the subsoil into groundwater aquifers. Pharmaceutically active compounds (PhACs) are chemicals used in human diseases treatment and animal husbandry. These compounds are not eliminated in human body, but they are conjugated and excreted with urine and feces and are in turn discharged to wastewater treatment plants. In semi closed urban water cycle where effluent water from wastewater treatment plant is discharged to receiving water bodies and indirectly used as influent water by water treatment facility, a wide range of contaminants such as pharmaceutically active compounds (PhACs) may end up in drinking water. Drinking water treatment works use a wide spectrum of processes, but most of these processes are not designed to remove PhACs.

Laboratory-scale batch and soil column experiments were carried out to simulate attenuation and pathways of pharmaceutically active compounds in riverbank. Maas river water (MRW), secondary effluent (SE) in 50:50 ratio, Maas river water amended with synthetic organic matter (SOM, ozonation BPDs) and plant-derived water were used as influent. Silica sand of size 0.8 – 1.25 mm was used as a filter media. PhACs and odour compounds (geosmin and 2-MIB) measurement was conducted at TZW and TU-Dresden (Germany) respectively. Most targeted compounds were removed above 90%, in 60 days retention time in laboratory-scale batch experiments. However, gemfibrozil, diclofenac and clofibric acid were less removed in plant-derived water due its less biopolymer fraction of BDOC. Moreover, carbamazepine was persistent. Geosmin and 2-MIB were eliminated in batch experiments in the first 30 days retention time. Long soil columns were conducted to study effect of redox conditions and addition of secondary effluent to Maas river water on fate of PhACs. Removal of targeted PhACs was similar in both oxic and anoxic conditions, except for carbamazepine which was persistent. Addition of SE reduced removal of gemfibrozil, diclofenac and bezafibrate by more than 15%. Geosmin and 2-MIB were removed above 80% during oxic and anoxic conditions. In short soil column study conducted to investigate removal mechanisms of PhACs in RBF, removal of bezafibrate, diclofenac, gemfibrozil and ibuprofen decreased by more than 20% in TW (ATP = 15 pg ATP/g) compared to MRW+SOM (ATP = 48 pg ATP/g). Removal of hydrophilic compounds of phenacetine, paracetmamol, pentoxifylline and caffeine from more than 90% in tap water and MRW+SOM to less than 20% in demineralised water spiked with 40 mM sodium azidw (ATP = 0.4 pg ATP/g). Geosmin and 2-MIB were removed above 90% in soil columns with tap water and MRW+SOM (biotic) while their removal decreased to 75.3% for geosmin and 66.6% for 2-MIB in soil column fed with demineralised water spiked with sodium azide (abiotic).

H.W. Simarmata (2010). QSAR-Based Model for Assessment and Prediction of Organic Micropollutants Removal during Bank. UNESCO-IHE MSc Thesis MWI 10.03.

Recently organic micropollutants have become a concern in scientific world related to their fate and transport in the aquatic life. Pharmaceuticals are a group of organic micropollutants that have been detected as a major contaminant in environment mainly due to uncompleted process of pharmaceuticals removal of wastewater treatment plants. A significant rise at consumption and application of pharmaceuticals recently has increased concentration of pharmaceuticals in aquatic life and may contaminate groundwater even further. Due to the persistence and mobility of pharmaceuticals in environment, it is believed that pharmaceuticals may cause toxic effect in human life although not much information is available to answer this issue.

Bank filtration is a robust technology used for water treatment that has high potentials for removal of different contaminants, including some pharmaceuticals and other emerging pollutants, from surface water at low cost. However, previous studies on fate of pharmaceuticals during riverbank filtration do not provide sufficient information or basis for a sustainable design and implementation of riverbank filtration systems for removing these contaminants. Furthermore, experimental data on organic micropollutants removal during soil passage is limited and doing experiment is time consuming and relatively expensive especially for increasing number of pharmaceuticals being produced recently.

To address this problem, this study focused on analysis of the available data and development of QSAR-based model using the physicochemical properties of pharmaceuticals in order to describe the fate of pharmaceuticals during riverbank filtration. Extensive literature review was conducted and removal data for different classes of pharmaceuticals were complied, along with the process and site conditions, in the form of a database. Several descriptors that represent physicochemical properties of pharmaceuticals were calculated by using different commercially available software packages. The best descriptors subsets for the models were selected using the genetic algorithm and then the developed model was analysed further by multi-linear regression.

Based on the data analysis, preliminary guidelines for the estimation of removal of six different classes of pharmaceuticals based on travel time and travel distance were developed. These guidelines can be used as a screening tool to assess removal of pharmaceuticals during bank filtration under given conditions. Using the removal database and molecular descriptors compiled, 8 QSAR models were developed and compared with the observed values from the database. This study showed that residence time is the most important variable that contributes significantly in almost all of QSAR models developed. Another prominent descriptor for pharmaceutical removal was nCp, which is number of terminal primary carbon present.

Five QSAR models developed (analgesics, antidepressant, beta blocker, blood lipid regulator and steroid hormone) have a good correlation between predicted and observed values. On the other hand, models for antibiotics, anticonvulsant, and x-ray contrast agents showed poor performance.

M. Babu (2011). Effect of Algal Biofilm and Operational Conditions on Nitrogen Removal in Wastewater Stabilization Ponds. UNESCO-IHE PhD thesis.

Domestic wastewater is a source of nitrogen in environmental systems. Nitrogen is known to be a major pollutant to the aquatic system. It causes eutrophication which leads to excessive algal growth or growth of other undesired water weeds such as water hyacinth. This results in disruption of the oxygen balance, release of toxins, loss of biodiversity and increased costs of water treatment; if the water resource is used as a source for drinking water production.

Wastewater stabilization ponds are treatment technologies that have been adopted by many developing countries. This is due to being cheap to construct, operate and maintain than activated sludge systems. However, they suffer from high effluent total suspended solids concentration (TSS), short-circuiting, long hydraulic retention time and ineffectiveness in removing nutrients like nitrogen. The problem of nitrogen removal is attributed to low nitrifier biomass present in the water column. Several studies have shown that the introduction of attachment surface for nitrifiers in the ponds improves nitrogen removal. However, information on the introduction of baffles as attachment surface for nitrifiers under tropical conditions is scarce.

This study focused on the effects of incorporation of baffles in pilot scale wastewater stabilization ponds. The pilot scale ponds were constructed at Bugolobi Sewage Treatment Works (BSTW) in Kampala, Uganda, and operated under tropical conditions. Settled wastewater was pumped from the sedimentation tank of BSTW into a 10 m^3 plastic anaerobic tank (AT) having a retention time of 3 days. The wastewater was then fed continuously by gravity at a flow rate of 2.1m^3 per day into a facultative pond (FP). The effluent of the FP was fed into four pilot scale maturation ponds (MP) of length, width and water depth of 4m by 1m by 0.8m at flow rates of 0.5m^3 per day. The details of the design and operation of the pilot scale are presented in figure 2 chapter 2 of this thesis. Pond 1 was operated as control while in ponds 2, 3 and 4, fifteen baffles of the same surface area were installed. The baffles had different configurations (pond 2: parallel to the flow, pond 3 and 4: perpendicular to the flow) inducing different horizontal and vertical flow patterns. The ponds were operated for two periods i.e. under an influent BOD of 72±45 mgl^{-1} and ammonia of 34±7 mgl^{-1} (period 1) and an influent BOD of 29±9 and ammonia of 51±4 mgl^{-1} (period 2). Introduction of baffles in wastewater stabilization ponds can affect their ecology, hydraulic characteristics and performance. This was studied and presented in different chapters. Laboratory studies on bulk water and biofilm nitrification rates were conducted, to complement the pilot scale studies.

The results of this study showed that nitrogen removal from wastewater can be improved by addition of extra attachment surface for nitrifiers. Experiments discriminating biofilm and bulk nitrification rates showed that biofilm nitrification rates were more important than bulk water nitrification rates (Chapter 4). Further laboratory experiments also showed that biofilm nitrification rates are significantly reduced

at bulk water oxygen concentration of less than 3.2 mg l^{-1} (Chapter 5). The results for the pilot scale wastewater stabilization ponds showed that during period 1, the control pond performed better than the ones that had extra attachment surface (Chapter 6). Under such conditions, it was found that the bulk water TSS was high and this prevented light penetration into the deeper parts of the ponds resulting in reduction of aerobic biofilm area that is required for nitrification (Chapter 2). The higher BOD during period 1 also favored the growth of heterotrophic bacteria compared to the nitrifiers. Nitrifiers are slow growers and under high BOD loading, they are outcompeted by heterotrophic bacteria. When the light conditions and corresponding algal activity of the FP were changed to increase the ammonia concentration in the influent to the maturation ponds (by covering it with a black plastic sheet) in period 2, the influent BOD of the maturation ponds decreased. Under these conditions, it was found that the baffled ponds 2, 3 and 4 showed better N-removal than the control pond 1. The removal efficiency was attributed to more attachment surface for nitrifiers in ponds 2, 3 and 4. The TSS of the maturation ponds also decreased, allowing more light penetration hence more aerobic biofilm area became available to the nitrifiers. Additionally, the lower influent BOD during period 2 favored the growth of nitrifiers in the ponds. Therefore under these conditions, nitrogen removal in the baffled ponds became better than in the control pond. Among the baffled ponds, pond 3 performed better than ponds 2 and 4. The mean HRT of pond 2 was 7.5 days while that of pond 3 was 9.2 days (Chapter 3), this could explain the differences in performance. However, the mean HRT for pond 4 was 9.9 days, higher than that of ponds 2 and 3; the reason why its performance was lower is unclear. It may be a result of differences in the hydraulic flow and oxygen balance. This study showed that introduction of baffles in wastewater stabilization ponds affects both the ecology and the hydraulic characteristics of the ponds. The algal and zooplankton distribution in the four ponds differed, but how this related to the nitrogen removal is still unclear. The tracer study showed that the flow patterns of ponds 1 and 2 were similar indicating that the baffle arrangement in pond 2 did not affect the flow pattern. However, the tracer curves for ponds 3 and 4 were different and these ponds had a higher mean hydraulic retention.

This study also showed that nitrogen uptake by algae is significant in wastewater stabilization ponds. However, internal nitrogen cycling is known to occur when the dead algae in sediments are decomposed resulting in a release of nitrogen. Some of the nitrogen incorporated in algal biomass leaves the ponds through washout. The pH in the ponds was mostly below 8 hence ammonia volatilization was probably negligible. Total nitrogen mass balances showed that nitrification-denitrification was the major nitrogen removal mechanism (Chapter 7).

PhD research Alberto Galvis (UNESCO-IHE and UNIVALLE) (ongoing): Development of a Technology Selection Model for Pollution Prevention and Control in the Municipal Water Cycle.

During the last decades, the concentration of population in urban areas and water consumption for different purposes has increased water problems. In most cases, the used water is returned to water resources as untreated wastewater, generating pollution and affecting the quality of life in communities, with the subsequent economic, social and environmental impacts. Recently, water has become intrinsically related to sustainable development issues and since 2001 with Millennium Development Goals (MDG). The achievement of these goals, several of them with a strong relationship with the water, it requires considerable investments and innovative strategies that optimise these investments.

The analyses carried out have shown that one of the mechanisms with the greatest impact on water resource protection is the correct choice of technological solutions for pollution control from municipal wastewater. However in many regions, especially in developing countries, the technology selection and its support tools (models, guides, algorithms, etc.) have been focused mainly to the wastewater treatment plants ("end of the pipe" solutions). In the last decades developed countries have proposed some models in the river basin context, but they do not involve with enough details the technology selection for wastewater treatment plant and the reuse option, while others are more focused towards hydrology and water supply for different uses, without considering key aspects such as the natural or stimulated self purification capacity of the water receiving bodies.

This research is oriented towards the development of a new conceptual technology selection model that retrieve the Three Step Strategic Approach to wastewater management (3-SSA) concept (Nhapi and Gijzen, 2005), not only in the urban water cycle, but also in the water basin, considering it as the analysis unit. The model to be developed includes cleaner production concepts like minimisation and prevention, the wastewater treatment for reuse and considering the self-purification capacity of the receiving water body as essential elements in the technology selection process. Additionally, it considers local conditions, regulations, the water sector policies, the water uses and the space and time distribution in order to optimise and to prioritize the pollution control investments. The study area for the development of this model is the Cauca River Basin in Colombia.

PhD research Juan Pablo Silva (UNESCO-IHE and UNIVALLE) (ongoing). Greenhouse Gas Emissions from Eco-technological Wastewater Treatment Systems.

During the last 200 years the atmospheric concentrations of greenhouse gases (GHGs) have been increasing. Human activities as the agriculture, industry, waste disposal, deforestation, and especially fossil fuel have been producing increasing amounts of GHGs. For example, the concentrations of CO2 increased from approximately 280 part per million by volume (ppmv) in pre-industrial age to 372.3 ppmv in 2001 and it will continues increase at about 0.5% per year (IPCC, 2001) whereas current CH_4 atmospheric concentration is going up at a rate 0.02 ppmv.yr-1. Furthermore, the annual source of N_2O have been increased from the surface of the Earth by about 40–50% over pre-industrial levels (Hirsch et al., 2006). As a result, variations in the radiative forcing of Earth's atmosphere could be being produced, so leading to large and rapid changes in the earth's climate due to global warming produced by these gases.

On the other hand, the eco-technological systems for wastewater treatment (ESWWT) are based in natural processes and provide a high removal of organic carbon, nutrients and pathogenic microorganisms from wastewater. Furthermore, they allow recovering energy, nutrients and water of the wastewater treated, thus their application in developing countries can be appropriated. However, the different transformations and biochemistry processes of organic and nitrogen matter carried out in ESWWT produce GHGs emissions, thus contributing to global warming.

Therefore, this PhD research will be focused in both the estimation of greenhouse gases from wastewater treatment systems (ESWWT and conventional) and the assessment of some processes that influence the GHGs production in ESWWT. First, an inventory of greenhouse gases from ESWWT and conventional wastewater treatments will be done. Then, the processes related with GHGs emissions from stabilization ponds (anaerobic, duckweed and algae facultative ponds) and constructed wetlands will be evaluated. Issues such as, environmental factors (pH, temperature, dissolve oxygen, solar radiation), operational aspects (organic load), and vegetation influence in constructed wetlands and duckweed pond will be studied. Finally, a comparison of greenhouse gas emissions from Eco-Technological and conventional wastewater treatment systems using a life cycle assessment (LCA) approach will be performed.

R. Shrestha (2007). Possibilities for Recycling Domestic Wastewater with Vertical Flow Constructed Wetlands. UNESCO-IHE thesis ES 07.44.

Making potable water and good sanitation accessible to all is one of the major challenges of the 21st century. Small scale onsite wastewater treatment technology can help to some extent to fight the challenge. In this context, a study was carried out to investigate the possibility of using small scale, low cost, decentralized wastewater treatment options for isolated areas. The research focused on the performance capacity and efficiency of Vertical Flow Constructed Wetlands from two sites: ZIN (a conference building) and geWooNboot (a houseboat), in treating the wastewater. Possibilities for potable and non potable reuse of treated wastewater were also explored. The effluent from the wetlands in the houseboat is further treated using a coal filter, a decalcifying filter, a fiber filter and a Reverse Osmosis system as an extra effort to make water potable. Performance of the wetlands was evaluated on the basis of concentration based removal efficiencies and mass removal rates. The effluent quality was compared with different discharge standards and reclaimed water guidelines. The results indicated that CWs were very efficient in removal of BOD, COD and were less efficient in nutrient removal. So the treated wastewater could not meet the discharge standards of sensitive areas while it could meet the standards for agricultural area. Despite of iron grit and calcium addition in the wetlands media, TP removal efficiency was still low. High pathogen concentrations in the effluent were observed, indicating the need for further disinfection before reusing the wastewater. From the literature review made during the study it can be concluded that the addition of a horizontal flow bed might help in decreasing the pollutants level. Despite of recycling treated wastewater in the houseboat, NO_3-N was not removed effectively, leading to high concentrations in the treated water. Moreover, continuous building up of pollutants was observed due to the short and closed water cycle in the houseboat. Though the water generated through Reverse Osmosis was free of bacterial contamination; certain parameters like pH, conductivity and nitrate concentration were not within the range of drinking water and thus the water might cause adverse health effects. From all this it can be drawn that generating potable water from wastewater in the houseboat was not the best option. Installation of a dry toilet and reusing only grey water can make the recycling more effective. Using rain water for producing drinking water could also be a better option; however the water volume collected from the roof was not sufficient so replacing the existing green roof by a normal roof would increase the water collection.

Muzola, A. (2007) Grey water treatment using natural wetlands. KNUST MSc thesis.

Greywater in Ghana does not receive any adequate treatment before it is discharged into drains, streams and wetlands. As a result the receiving streams and rivers have become polluted (Awuah et al, 2002). An alternative approach in addressing this situation is the adoption of natural wetland treatment system, which offers low construction and maintenance costs. The natural wetlands systems at Kwame Nkrumah University of science and technology of Kumasi/Ghana were used in this case study. The objective of this study was to determine the potential of natural wetlands in treating Greywater from some halls of residence at Kwame Nkrumah University of Science and Technology Campus. Characterization of the Grey and the contaminant removal efficiency were done through analysis of influent/ effluent quality and material balance. The study was conducted over eight week's duration. Best performance was obtained at suspended solid removal efficiency of 98.8%. Results of the Greywater characteristics analysis show that the removal efficiencies of the Turbidity, Suspended Solids, COD, BOD, Total Coliform were ranged between 85-99%; Phosphates and Nitrite-N ranged between 70-85%; Conductivity and Nitrate –N were less than 50%; heavy metals (Mn and Pb) were less than 50%, Cu and Fe ranged between 50-70% , Zn was 78.8%, and Cd increased by 51% meaning there was probably some leachates from the wetland soil or accumulation of Cd in the soil. These ranges after treatment gave good results compared to Environmental Protection Agency of Ghana effluent discharge guidelines for wastewater being discharged into waterbodies.

These results show that the greywater has less pollution potentials after treatment in the natural wetland. The inflow greywater ratio of COD to BOD was 1.7:1. The heavy metals concentrations in the soil were as high as 1890.69mg/kg for the Fe. The soil were sandy loam with the clay portion less than ideal distribution for wetland soil of 15%. The inflow rate was 7.16 l/s and outlet flow rate was 45% of inlet flow rate. The Hydraulic loading rate was 1.4cm/d.The wetland species present in the natural wetland were predominantly *Colocasia esculenta*, *Xanthosoma* sp, *Thala* sp. and *Coix lacryma* (job's tears), contributing to the efficient removal of the pollutants. The natural wetland has the potential for treating the Greywater.

NIYONZIMA, P. (2007) Grey water treatment using constructed wetland at KNUST in Kumasi. KNUST MSc thesis.

Constructed wetlands are current the most widely recognized wastewater treatment option, especially in developing countries where they have the potential for improving water quality and creating valuable wildlife habitat in ecosystem with treatment requirement relatively simple for operation and maintenance cost. Lack of grey water treatment facilities at Kwame Nkrumah University of Science and Technology (KNUST) Kumasi, Ghana, causes pollution in the main drainage Wiwi stream. In order to assess the potential of constructed wetlands in treatment of grey water at KNUST; a Horizontal Sub-surface Flow pilot-scale constructed wetland was designed, constructed and operated on the KNUST campus in the flood plains of the Wiwi stream bridge on the left side of Duncanson road from Administration. The study was carried out in a sedimentation tank of 3.65 x 0.65 x 0.4 m deep and a Horizontal Sub-surface constructed wetland of 3.5m x 0.8m x 0.8m deep. The grey water flow rate of 0.48 m^3/d was flowed through vegetated wetland and sandy pilot plant. The filter media consisted of 0.6 to 2 mm of coarse sand, 368.78 cm^3/d of hydraulic conductivity and cattails (*Typha latifolia* spp) were used as plants species. The effluent flow rate of the plant was 0.327 m^3/ day and the retention time was 15hrs. 72% to 79% of BOD, COD, SS, Grease, and Faecal Coliform removal were achieved, while the nutrients (Nitrogen and Phosphate) removal was the range of 34% to 53%. There was no significant difference between the morning and evening results (P > 0.05). The effluent characteristics did not meet the EPA (Ghana) guidelines primarily because the organic load of the waste water discharged into the wetland was much than anticipated.

A.M.M. Ali (2007). Water quality enhancement in Sloterbinnenpolder (Amsterdam, The Netherlands) by adopting ecological engineering approaches. UNESCO-IHE MSc Thesis ES 07-17.

Sloterbinnenpolder (SBP) is very problematic with regard to surface water quality. The water bodies in the polder are suffering of high load of nutrients (mainly phosphorus) which caused eutrophication problems especially in the Sloterplas lake. Therefore, the main goal of this research was to improve the water quality in Sloterbinnenpolder.

To achieve this goal, identification of the sources of phosphorus loads (as the main limiting nutrient) to the Sloterplas Lake and assessment of different proposed measures that can reduce external loads, and accelerate the self-purification capacity of the Lake were carried out. The research assessed ecological engineering measures and conventional engineering methods that could reduce phosphorus in the polder.

It was concluded that both internal phosphorus load (32% of the total load) and external phosphorus load (68% of the total load) to the lake are contributing to the lake eutrophication problem, so attention has to be paid for both internal and external loads in order to restore the lake. In addition, it was found that the runoff, pumps, and inlet are the most important external loads contributors, where they represent about 99% of the total external loads.

The research results showed that the external phosphorus loads reduction that could be achieved by runoff treatment by ecological engineering (BMPs) and treatment of the pumps and inlet flow rates was quite high (75%), but was not enough to restore the lake due to the natural background loads, and the extensive internal load.

T. Munezvenyu (2008). Effect of some environmental factors on nitrification in algae-bacterial biofilm. UNESCO-IHE MSc thesis ES 08.37.

Numerous wastewater treatment technologies are costly and require a high level of technical expertise. Waste stabilization ponds are low-cost systems and do not lower level of technical expertise for maintenance. They are thus appropriate technologies for use in developing countries and are also effective in a developed country context. Although WSPs are effective for
BOD and pathogen removal, they have not been effective in nitrogen removal due to the unavailability of attachment sites and subsequent washing out of nitrifying bacteria.

Two continuous flow lab scale ponds were set up to investigate the effect of pH and algae on algal-bacteria biofilms ammonia and nitrogen removal in facultative ponds. Baffles were added to the ponds as biofilm attachment sites. Overall ammonia removal efficiencies were found to range for 15- 28% for the algal-based ponds and 6-12% in the non-algal-based pond. Nitrification was identified to be the main mechanism for ammonia removal. This shows that adding attachment surfaces for development of algae-bacterial biofilms has great implications for improving the nitrification in WSPs.

In order to incorporation algae-bacterial biofilms into full-scale ponds, a better understanding of the functioning of these biofilms is required. Further studies into the effect of some environment conditions on algae-bacterial biofilms were carried out. Biofilm plates grown from the labscale ponds were then used to conduct a series of batch tests to study the effect of pH and the absence of algae on biofilm nitrification rates. Batch tests showed that for a pH range of 5-9, the maximum nitrification rates occurred at pH 7. This is different from maximum nitrification rates found for pure cultures of suspended cells, which ranged between pH 7.9 -8.3. This implies that the behaviour of algae-bacterial biofilms may differ from that described for suspended cells.

Algal-bacterial biofilm was found to have a 6.8 times higher nitrification rate than bacterial biofilm with rates of 4.42 and 0.65 mgN/m^2/h respectively. The results suggest that algae contribute to the development of a heterogeneous biofilm community more productive for nitrification than heterogeneous biofilm formed in the absence of algae. It can be concluded that attachment sites increase pond nitrification rates and that the optimum pH for activity of suspended nitrifying cultures differs from that of nitrifying cells in biofilms. Furthermore, algae may play a part in biofilm interactions that contribute to better nitrifying activity.

Ansah, M. (2008) The use of natural systems for the treatment of greywater: A case study of Kpeshie lagoon. KNUST MSc thesis.

Handling of wastewater (greywater and blackwater) in urban areas is a big problem. This is not an exception for the La Sub Metro. Due to lack of wastewater treatment facilities, almost all the wastewater in the Sub Metro are discharged into the Kpeshie Lagoon without pretreatment. The objective of this study was to determine the potential of natural system (Kpeshie Lagoon) for treating greywater through the characterization and determination of influent and effluent water quality of the Kpeshie Lagoon. Characterization of greywater was carried out after four weeks of sampling process and the parameters analysed were as follows: colour, turbidity, pH, salinity, BOD, COD, conductivity, TSS, nutrients and trace metals. The results indicated that the lagoon has a high potential of treating greywater if managed well. The parameters that showed high removal efficiency were: 80% nitrates, 78% colour 74%BOD and 61% turbidity.

ANTWI-AGYEI, P. (2009) Faecal sludge management: the case of Madina. KNUST MSc thesis.

This study was carried out to determine the management arrangements in place for faecal sludge at Madina in the Ga East Municipality of the Greater Accra Region of Ghana. Five (5) main toilet technologies were identified at the household level in the town: Water Closet (WC) with septic tanks - 47%, Kumasi Ventilated Improved Pit Latrines (KVIP) – 9%, Ventilated Improved Pit Latrines (VIP) – 14%, Pit Latrines – 27% and bucket/pan latrines - 3%. Results showed that 65% of the people owned and used household toilets (63.1% of these toilets were improved toilet facilities and not shared) and 23% used public toilets (shared toilet facilities) in Madina. Eleven percent (11%) of the respondents practiced open defaecation with 1% practising defaecation in polythene bags. Excreta from KVIP and WC with septic tanks were collected and sent for treatment using a waste stabilisation pond. The excreta from the bucket/pan latrines, pit latrines and VIPs were collected and transported manually and discharged untreated into open

drains, in the bush or in rivers. The average household spends 8.3% of its annual income on faecal sludge management. Cost recovery mechanisms adopted by the Assembly and commercial toilet operators were user charges from public. However this was not adequate for

proper operation and maintenance of the facilities. Schools could not afford the cost of

operation and maintenance of their toilets. Thirty-Two percent and Sixty-Five percent of the respondents were satisfied and not satisfied respectively with the faecal sludge management arrangements in place. The major problem for effective management of faecal sludge was weak enforcement of sanitation bye-laws and regulatory framework. It is recommended that household latrines should be encouraged. Sanitation bye-laws in the community should be enforced. There should be an integrated approach of stakeholders‟ participation in both the planning and implementation stages of all faecal sludge management service delivery. Higher priority should be given to faecal sludge management. All public toilet operators should be trained for effective operation and maintenance of the toilets. The performance of the treatment plant should be evaluated for possible reuse and recycling of accumulated sludge.

A.F. Saeed (2009). Laboratory study on the emissions of N$_2$O, CH$_4$ and CO$_2$ from activated sludge. UNESCO-IHE thesis ES 09.21.

The last 200 years, has witnessed human activities in agriculture, industry, waste disposal, deforestation and most significantly fossil fuel producing unprecedented impacts on levels of GHGs, thus changing the composition of these gases in the atmosphere. One of the main sources of these GHGs is wastewater treatment, where it expected grow. The quest to meet the needs of the ever increasing human population is exerting a significant pressure on the global environment. The Millennium Development Goal 7 aims to ensure that by the year 2015, the proportion of people without access to portable drinking water and adequate basic sanitation is halved. This calls for accelerated expansion in portable water facilities. However, the use of water is associated with wastewater generation since about 75-85% of water used is returned as waste. As long as populations grow significantly, GHGs from wastewater sources will continue to have a major influence on the upward trends in CO$_2$, CH$_4$ and N$_2$O emissions. Whereas it is obvious that wastewater treatment systems have a great potential in controlling water pollution from both point and non point sources, it is not certain if the secondary environmental burden and effects in terms of GHGs emissions makes them environmentally sustainable. This research is thus an attempt to identify and quantify the GHGs particularly N$_2$O, CO$_2$ and CH$_4$ from an activated sludge wastewater treatment system under different temperatures and nutrient conditions. Active sludge samples from the Aerobic tank (AE), Anaerobic Digester (AN) and Denitrifying (Anoxic) tank (DE) of an activated sludge wastewater treatment system were incubated under four different temperatures namely 4°C, 20°C, 30°C and 37°C. Gas samples were collected and analysed in GC with specific settings to identify N$_2$O, CO$_2$ and CH$_4$. Experiments were also conducted under altered nutrient (15mg/l & 30mg/l nitrate and 30mg/l ammonia) concentrations and shaking (100rpm) at 30°C. The results showed that elevated temperatures promote higher releases of N$_2$O, CO$_2$ and CH$_4$. Higher nitrate concentrations positively influence the release of N$_2$O and CH$_4$ but have no influence on CO$_2$ release. The relatively lower emissions measured for N$_2$O at 4°C and 20°C were due to a slowdown of the denitrification and nitrification processes at lower temperatures. Furthermore, the lower emissions of CO$_2$ and CH$_4$ at 4°C and 20°C were also attributable to a slowdown of biological activities at lower temperatures. Shaking at 100rpm led to less N$_2$O, CO$_2$ and CH$_4$ emissions. Additionally, it was found that activated sludge treatment system is an important source of GHGs with the anaerobic sludge having the highest potential for the release of the most important GHGs (N$_2$O, CO$_2$ and CH$_4$)

J.E. Holguin (2009). Modelling the ecological impact of wastewaters on the Cauca River (Colombia). Ghent University MSc thesis.

The Cauca river is one of most severe cases of contamination for domestic and industrial wastewater discharges in Colombia. The rapid urbanization and major economic development in the Cauca river´s geographical valley has led to dramatic degradation of the environment and increased health risks due to inefficient processing of the increased pollutant load effluents and solid wastes. This river during the year 2005 received in average 195 tons of organic matter load per day in terms of BOD5 in the study zone. The high discharge of organic matter causes a high oxygen demand in the degradation process. Thus, one of the most sensitive problems in the Cauca river is the decrease of dissolved oxygen (DO) with concentrations near to zero (0) mg/l in some monitoring stations especially during dry season (low flows conditions). Low DO levels affect the ecosystem equilibrium and the functioning and survival of biological communities. For this reason, the main objective of this research is to contribute to the integrated water quality management of the Cauca river in Colombia, developing a mathematical model to investigate the ecological quality of this river under actual conditions as well as after different restoration actions.

The approach followed was to build statistical models that allow predicting the occurrence (multiple logistic regression models - MLRMs) and the abundance of macroinvertebrates (quasi-Poisson regression models - QPRMs) in this river under different conditions. Afterwards, an integration of these ecological models with the hydrodynamic and physical- chemical water quality model MIKE11 was performed. Finally, applications of the integrated ecological modelling were made for predicting the ecological impact of the scenarios for pollution control in the Cauca rivers basin.

The assessment of the MLRMs reliability showed that the models for Ephemeroptera (AUC=1), Trichoptera (AUC=1), and Haplotaxida (AUC=0.926) correctly discriminates between occupied (presence) and unoccupied (absence) sites in the dataset. Regarding the predictive validation procedure for QPRMs, it was found that in general the models reproduce with good precision the tendencies and the maximum and minimum values of abundance data for each macroinvertebrate (i.e. Ephemeroptera, Trichoptera and Haplotaxida) and the BMWP index, with high R^2 values ($0.866 < R^2 < 0.998$).

The application of the integrated ecological modelling of the Cauca river showed that the MLRMs and QPRMs predict well the ecological impact of the scenarios for pollution control in the Cauca rivers basin. Thus, in the scenario with the highest pollution reduction an improvement of the water quality of the Cauca river is achieved, which is represented with the presence and/or an increase of the number of pollution sensitive benthos (i.e. Ephemeroptera and Trichoptera) and the absence and/or a decrease of the number of pollution tolerant benthos (i.e. Haplotaxida). On the other hand, if the worst pollution condition scenario is considered a deterioration of the water quality is obtained, which is represented with the absence and/or a decrease of the number of pollution sensitive benthos and the presence and/or an increase of the number of pollution tolerant benthos.

The integrated ecological model proposed in this research is a powerful operational tool, which allows to model and to assess the ecological impact of wastewater discharges into the Cauca river and can help to calculate the needed reductions in wastewater discharges of organic matter to meet biological quality criteria in this river.

A. Valverde Solis (2010). Estimacion de gases de efecto invernadero en humedales construidos de flujo subsuperficial horizontal - Estimation of greenhouse gas emissions from horizontal subsurface flow constructed wetlands. UNIVALLE MSc thesis.

Los Humedales construidos son sistemas sencillos, de bajo costo de operación y mantenimiento, eficientes a la hora del tratamiento de las aguas residuales. Atractivos Para países envía de desarrollo. Sin embargo, al reducir los nutrientes y cargas contaminantes de las aguas residuales, estos pueden generar algunos subproductos como Metano, Dióxido de carbono y Óxido nitroso, Llamados gases de efecto invernadero, que a su vez generan problemas ambientales al contribuir al calentamiento global.

De este modo, partiendo de la reducción y transformación de materia orgánica y nutriente, por procesos físicos-químicos y biológicos del agua residual en Sistemas Naturales, se estimó la emisión de gases de efecto invernadero en Humedales construidos de Flujo Subsuperficial Horizontal.

Para esto, se operaron tres unidades de *HFSS* a escala real, dos fueron sembrados con plantas ornamentales, uno con *Heliconia psittacorum*, otro con *Phragmites australis* y un tercero sin sembrar. Todos ellos sometidos a una carga hidráulica de 3.5 m^3 d^{-1}, que equivale a un tiempo nominal de retención hidráulico de 1.8 día. Caracterizaciones fisicoquímicas, fueron realizadas, al estimar las emisiones de Gases de Efecto Invernadero (CO_2,CH_4,N_2O). Utilizando la técnica de la cámara cerrada.

Los resultados obtenidos, indican que la eficiencia de eliminación de la DQO afluente estuvo entre el 66.2 y 87 %.En los sistemas sin plantar y plantados, respectivamente. La temperatura promedio de la cámara cerrada fue *de 29 y* 31ºC, el Potencial de Óxido Reducción-*Eh* (ORP) oscilo entre -167 *a* -108 mV. En el sistemas control y plantados *respectivamente* mientras el pH fue casi neutro en todos los sistemas (6,3 a 7). La emisión promedio de gases para el sistema sin plantar (control) fue (-0.002CO_2, 5CH_4) g.m^{-2}d^{-1} y 0.013N_2O mgm^{-2}d^{-1} y los plantados con *Phragmites australis* (0.052CO_2, 6.1CH_4, 0.016 N_2O mg.m-2d-1; *Heliconia psittacorum* (-0.003 CO_2, 3.3 CH_4) g.m^{-2}d^{-1} y 0.005 N_2O mg.m^{-2}d^{-1} respectivamente.

Finalmente, los humedales construidos de este estudio, tuvieron tendencia de sumideros de Dióxido de Carbono (CO_2), emisores de metano (CH_4) y Óxido Nitróso (N_2O). Estas, no fueron estadísticamente significativa entre los tratamientos, Sin embargo, fueron eficientes en la reducción y transformación de contaminantes. Por tanto, siendo emisores y sumidero de GEI. Estos pueden ser una solución viable a problemas económicos y de contaminación al comercializar las plantas ornamentales y descontaminar las aguas residuales de muchas comunidades principalmente en los países en desarrollo*.*

C.L. Suarez Marmolejo (2010). Tratamiento de aguas residuales municipales en el Valle de Cauca - Treatment of municipal wastewater in Valle del Cauca. UNIVALLE MSc thesis.

The main aim of this research was to contribute to the enhancement of the wastewater plant treatment performance from the region of the Valle del Cauca, in the areas of design, construction, operation, maintenance and performance. It was proposed as specific objectives to diagnose the plant wastewater treatment in the municipalities of Valle del Cauca Department, analyzing the information in the environmental agency on performance, identify water treatment plant (WWTP), define the critical factors that affect the operation and performance, and finally, propose strategies for the optimization of the evaluated wastewater treatment plants.

In the identification stage it was found out the dominant technology in the region is the treatment by stabilization ponds, and in second place is the UASB reactor configuration followed by a trickling filter. After the study of each technology it was identified the critical factors related with the design, such as an inadequate selection of the parameters and inappropriate configurations. Also it was found some aspects related with the wrong positioning of some operation units and the use of non-recommended materials in the construction. For the maintenance and operation it was found deficient periods of measurement and control of the process, i.e. long delay time for the measure of the process variables and not enough technical instruction to the operators of the plant.

It was proposed some strategies of optimization of the identified critical points based on the experience in other WWTP, which are under similar conditions with the studied plants, aimed to solve those limitations in a simple and practical way.

Despite the found limitation in the design, construction, maintenance and operation activities of the wastewater treatment plants, the adopted technologies were considered sustainable for the environmental and socio-economic situation of the region of the Valle del Cauca. Moreover, their efficiency is quiet acceptable. It's considered that other technologies for wastewater treatment different to the stabilization ponds and the configuration of a UASB reactor followed by a trickling filter could not work out better than them. However, it's required to pay more attention in the design and maintenance processes of the wastewater treatment plants to warranty the well performance of the system.

F. Montaña Duque (2010). Selección de Tecnología para la Recolección y Transporte de Aguas Lluvias y Aguas Residuales en Áreas Urbanas - Technology selection for the collection and transport of rainwater and wastewater in urban areas. UNIVALLE MSc thesis.

El desarrollo de áreas urbanas implica la provisión de sistemas de drenaje para la evacuación de aguas de escorrentía y aguas residuales. Aunque los alcantarillados combinado y separado han sido las tecnologías utilizadas tradicionalmente para tal fin, existen otras opciones que podrían ser implementadas de acuerdo a las condiciones locales. Las diferentes características de cada contexto, las múltiples opciones tecnológicas para el drenaje urbano y los problemas relacionados con conexiones erradas, reboses del sistema combinado y descargas del primer lavado al cuerpo receptor, dificultan la selección de tecnologías sostenibles para cada caso. Con el propósito de ayudar en la toma de esta decisión, se desarrolló un modelo conceptual de selección de tecnología para la recolección y transporte de aguas lluvias y aguas residuales en ambientes urbanos, con énfasis en aspectos tecnológicos. El modelo considera dentro de las alternativas de selección cinco opciones de sistemas urbanos de drenaje sostenible (SUDS), el drenaje superficial, el alcantarillado pluvial, el alcantarillado combinado, el alcantarillado sin arrastre de sólidos, el alcantarillado simplificado y el alcantarillado sanitario convencional. El modelo fue aplicado a un estudio de caso, donde se encontró que la opción más adecuada es implementar dos depósitos de detención junto con un alcantarillado combinado.

A.P. Lasso Palacios (2010). Cámaras estáticas para la estimación de gases de efecto invernadero en lagunas de estabilización para el tratamiento de aguas residuales domésticas. UNIVALLE MSc thesis.

Los sistemas de tratamiento de aguas residuales (STAR) han sido diseñados para prevenir y/o minimizar los impactos negativos de las cargas contaminantes de los desechos líquidos a los cuerpos de agua. Sin embargo, estos sistemas pueden generar gases como dióxido de carbono, metano y óxido nitroso. Estos subproductos secundarios son denominados gases de efecto invernadero (GEI) los cuales tienen el potencial de producir cambio climático.

Las emisiones de GEI provenientes de los STAR se han estimado en un 5% de las emisiones globales. Los inventarios de GEI generados en STAR tienen una alta incertidumbre especialmente en los países en desarrollo debido a la falta de información. Diferentes metodologías han sido empleadas para la realización de estimación de emisiones de GEI, especialmente los factores de emisión propuestos por el IPCC. Sin embargo, la falta de aplicación de metodologías para las estimaciones *in situ* de GEI es una de las principales deficiencias en la realización de inventarios de emisiones.

Acorde con lo anterior, para suplir los vacios metodológicos, en este trabajo se desarrolló un protocolo de medición de GEI en lagunas de estabilización para el tratamiento de aguas residuales. Tres tipos de cámaras estáticas fueron empleados para determinación de las emisiones de CH_4, CO_2 y N_2O. Una cámara estática simple, otra con ventilador y una con recirculación se compararon y se determinó que los mecanismos de homogenización en las cámaras no tienen influencia en la estimación del flux de los GEI. Los flux estimados fueron de 50.74 ± 33.45 $g.m^{-2}.d^{-1}$, 158.50 ± 59.36 $g.m^{-2}.d^{-1}$ y 5.11 ± 10.42 $g.m^{-2}.d^{-1}$ para CH_4, CO_2 y N_2O, respectivamente, en la laguna anaerobia. Por su parte en la laguna facultativa se obtuvieron flux de 5.42 ± 3.31 $g.m^{-2}.d^{-1}$, 3.72 ± 34.39 $g.m^{-2}.d^{-1}$ y 1.49 ± 5.93 $g.m^{-2}.d^{-1}$ CH_4, CO_2 y N_2O, respectivamente.

D.A. Zambrano (2010). Minimización y prevención como estrategia para el control de la contaminación por aguas residuales municipales en la zona de expansión de Cali - Minimization and prevention as strategies to control contamination by municipal wastewater in the expansion zone of Cali. UNIVALLE MSc thesis.

No abstract available

M. F. Jaramillo (2010). Potencial de reuso de agua residual doméstica como estrategia para el control de la contaminación por agua residual en el valle geográfico del río Cauca - Potential of reusing domestic wastewater as a strategy to control contamination by wastewater in the geographical valley of the Cauca river. UNIVALLE MSc thesis.

The potential of agricultural reuse domestic wastewater was characterized by three case studies in the Cauca river valley in the department of Valle del Cauca. The methodology for identifying potential can be divided into three stages that correspond to the documentation of experiences of agricultural reuse in the region, the implementation of socio-economic assessment as a tool to characterize the potential for agricultural reuse under the concept of sustainability and the development a proposal in the context of integrated management of domestic wastewater.

The results show that the implementation of the practice of agricultural reuse is determined by four factors: the financial factor, the technical factor, the environmental factors and cultural factors. These factors evaluated in the three case studies helped identify the potential of integrated agricultural reuse water management of WWTP-C, with a cost-effectiveness of $ 15.244 million and a benefit-cost ratio of 1,53. For the case study of wastewater management in the area of expansion, the conditions of temporary irrigation practice did not benefit positively the implementation of agricultural reuse. The benefit-cost ratio was 0,27 with economic efficiency -$8.487 million. In the case of treated waste water management in the municipality of Buga the benefit-cost ratio was 1,01, which presents a socio-economic terms indifferent decision to implement reuse. However, it is identified by modeling the quality of receiving water body, with the implementation of MIKE11 a positive impact on the OD concentration increased and decreased the concentration of BOD in the three case studies evaluated.

E. Cifuentes (in progress). Analysis of the impact of diffuse pollution sources related to the land use and management practices in the production of sediment in the Palo river basin. UNIVALLE MSc thesis.

The Cauca River is one of the most important rivers in Colombia, born near the lagoon of the Ox in the Colombian Massif. It is the main tributary of the Magdalena River and the largest interandean river in South America; The Cauca River basin is place for various productive activities and the sugar industry, coffee production, power generation, mining and agriculture meeting the water needs in over 180 municipalities in the departments of Cauca, Valle del Cauca, Quindío, Risaralda, Caldas, Antioquia, Córdoba, Sucre and Bolivar. The City of Cali is located in the upper basin where its waters are treated for human consumption. However, the Cali municipal utilities have to spend significant resources to treat high pollution that the river brings. It is estimated that in the case of progressive deterioration of water quality in the Cauca River, diffuse pollution has a significant impact and the Palo River Basin, the main tributary of liquid and solid flows, is considered a major contributors of this contamination.

This study attempts to provide a contribution to the relationship between diffuse sources of pollution and the uses and management practices of soil sediment production in the Palo River basin. This thesis has been done using modelling techniques, uses and land management practices information obtained in the field and Geographical information systems from which it links secondary information. That information has been supported by Space remote sensing tools.

This research is carried out under the context of SWITCH project that promotes a paradigm shift in water management and is led by Cinara Institute - University of Valle in Colombia. The SWITCH project focuses on pollution control in the context of integrated water resources management considering the point or diffuse sources, cleaner production concepts and minimization and prevention as an alternative to conventional solutions, which only consider wastewater treatment plants (final solution to the tube). In SWITCH, Cali is a demonstration City (learning area) and one case study to develop is the water quality of the Cauca River and its impact on the water supply system of Cali.

E.A. Jiménez Ríos (in progress). Proposal for applying sustainable urban drainage systems on the lower basin of the Cañaveralejo river. UNIVALLE MSc thesis.

Latin America and Colombia has suffered the ravages and disasters caused by hydrologic imbalance, whenever the winters are strong , cities and entire villages are at risk by the impact of torrential rains, leaving huge material losses, and human. Cali, for consequences of urban dynamics, grew rapidly, occupying high-risk areas such as Cañaveralejo River Basin. Eventually, causing problems for local residents during winter by the overflowing of the Cañaveralejo River, landslides caused by saturation in the soil, among other circumstances. Analyzing this situation has been taken to Cali as a demonstration city as part of the SWITCH project "Sustainable Water Management Improve Tomorrow's Cities Health". The project is focused to the development, application and demonstration of technological solutions and socio-economic strategies, for contribute to achieve an effective development and sustainable of urban water management thinking in "the city of the future", with a projection of 30 years from now.

In the framework of the project, the proposal about sustainable drainage system for lower basin of Cañaveralejo River is located within one of the three topics of the Learning Alliances. This case study have as objective contribute to improve the flood problems in winter period, minimising the non-point source pollution effect about Cañaveralejo River, and Cauca River, recovering the soil infiltration capacity, increasing the green areas, the creation of possibilities of water runoff reuse, and improving the living standards of people in the study area.

This document is composed by following chapters: a conceptual framework with the inputs of the investigation, subsequently, a literature reviews of the SUDS, a description of the study area, and finally presents the methodology.

Renata Kolasa (2005). Influences of the application of the three-year dose of sewage sludge on the biomass of the different type of the energetic willow. University of Lodz MSc thesis.

The goals of the master's thesis:

- Estimation of the quality and weight gain of the willow cutting.
- Estimation of the resistance of the different types of energetic willow on the vermin
- The evaluation of the efficiency of accumulation of heavy metals by different types of willow
- Estimation of the biomass production of the energetic willow in diversified ecohydrological conditions;

Methodology:

The experimental plantation has been divided into 4 experimental field (I, II, III, IV) with different clones of energetic willow. On the experimental plantation dose of sewage sludge, which was calculated based on the regulations of the decree of the Ministry of the Environment (Dz.U.Nr 134, position 1140) was applied. The dose of 11,5 tons/ha/years of sewage sludge was applied, which is equal to the 3-year dose.

Results:

1. The average survivability of willow maintained between 57% to 92% with the exception of the area III, where the survivability was about 10%
2. The obtained biomass reached values between 0,4 t d.w./ha/year (area I) – 1,4 t d.w./ha/year (area II). The relatively small crop is typical for the first year estimations (after the sanitary cutting).
3. The high resistance on the pest *Schizotetranichus schizopus* was observed by the *Salix* from area I and II.
4. The content of Zn in the plant tissues was the highest among the analyzed metals. The average value was: in the roots - 53 mg/kg d.w., in the leafs - 41 mg/kg d.w. and in the twigs - 31 mg/kg d.w. The range of total content of heavy metals in willow tissues was between 164,59 mg/kg d.w – 176 mg/kg d.w. The values differed between species and of plant tissues. The greatest amount of heavy metals was observed in the roots.
5. *Salix viminalis* from area I and II accepted low humidity (10%), but the *Salix viminalis* from area IV obtained the highest biomass on the area with the higher humidity (16%).

Mateusz Klonowski (2006). The use of phytotechnology in the utilization of the sewage sludge and compost on the Waste Water Treatment Plant in the City of Lodz. University of Lodz and European Regional Centre for Ecohydrology u/a UNESCO MSc thesis.

The goals of the master thesis:
- The estimation of the increase of biomass of the energetic willow
- The evaluation of the efficiency of the accumulation the heavy metals by the different type of willow

Methodology:
The experimental plantation has been divided into 4 experimental fields (I, II, III, IV) with different clones of energetic willow:
- experimental field number I: fields 1- 5, *Salix viminalis* clones;
- experimental field number II: fields 6 – 7, Tordis (*Salix schwerini x S. viminalis*) x *S. viminalis;*
- experimental field number III: fields 8 – 9, Tora;
- experimental field number IV: fields 10 – 11, *Salix viminalis* (clone 192) (authors: The City of Lodz Office);

The willow from area I, II and IV were planted in 2004, the willow on the area III were planted in 2005. The willow was also planted on the four complexes:
- XI (with compost)– Tordis
- XII (with compost) – *Salix viminalis* (klon 192)
- XIV (with compost and sewage sludge) – Tordis
- XIX (with compost) - *Salix viminalis* (klon 192)

Results:
This master thesis was a continuation of the previous study conducted in 2004-2005. During the study it was observed that from the experimental area higher biomass, higher amount of branch and higher content of metal than after first year were obtained

Maja Godowska (2008). Application of nucleic acids as the indicator in analysis of ecohydrological processes. University of Lodz and European Regional Centre for Ecohydrology u/a UNESCO MSc thesis.

Part of the thesis concerned the possibility of using ratio of RNA / DNA to assess the long-term anthropogenic stress. The study compared the RNA / DNA in perch *Perca fluviatilis* L. Perch caught from the three rivers in Central Poland: Sokołówka - urban river, flowing through the city of Lodz, Ner - the river receiving waste water from the Lodz agglomeration and Grabia - one of the cleanest rivers in Poland.

Analysis of the ratio of RNA / DNA in the perch from three rivers, showed a decline in this index, along with deteriorating environmental conditions. The lowest RNA / DNA ratio was observed in perch caught from Sokołówka, and the highest ratio of RNA / DNA was observed for perch caught from Grabia. The ratio of RNA / DNA in the tissues of fish could be recommended in biological monitoring, as an indicator of the water quality in rivers and as a screening method to assess the degree of long-term contamination of aquatic ecosystems including urban impact.

The research contributed to the SWITCH demonstration project on the Sokołówka River.

Michał Przybylak (2008). The influence of water flow on sedimentation in dam reservoirs cascade on Sokolowka. University of Lodz MSc thesis.

The research was conducted on five small urban water reservoirs in the northern part of Lodz. In order to investigate suspended sediments properties, over 45 samples of bottom sediments were collected and analysed in three different months.
The aim of the studies:
- Investigation of bottom sediments properties and its correlation with water flow
- Creation of two-dimensional water flow model, using CCHE2D 2.2.
- Comparison of results from laboratory analysis with computational water flow simulation.
- Creation water flow simulation in different flow conditions.

NCCHE modeling seems to be promising tool to improve management of urban water resources. These researches present example of application CCHE2D model and its verification in specific Sokolowka river condition.

Łukasz Nowacki (2008). Ecosystem biotechnologies – modification of ecosystem properties as a method of protection and renaturalization of water resources, the example of Sokolovka river revitalization project. University of Lodz MSc thesis.

Localization:
"Teresa" reservoir located on the floodplain of the Sokolowka river - a typical urban storm water drain in the northern part of Lodz.

The aim of the study: Creation of ecotone zone around the shoreline of water retention reservoir.
1.   Estimation of aquatic plant capability for nutrients (phosphorus, nitrogen) uptake.
2.   Evaluation of the potential use of aquatic palant communities as a tool for rain water management in specific conditions of Sokolowka river catchment.

Benefits from the study:
•   Increased sustainability, protection and improved management of water resources
•   Application of new approach to environmental problems – ecological engineering
•   New low-cost, high-technologies
•   Reduced risk in terms of droughts and flooding events
•   Translation of scientific innovation into practical application in The City of The Future

Magdalena Cichoń (2008). Identification of anthropogenic contamination in the Sokolowka river catchment. University of Lodz MSc thesis.

Regulation of natural river corridors connection/ link with elimination of vegetation and increased use of the catchment caused decline the carrying capacity of the Sokołówka river and increase in the transport of substances coming from agricultural catchment to the reservoir and water body. One of the methods is reclamation of degraded areas.

The aim of the research on the Sokołówka river was identification of the main threats (red points) of *Escherichia Coli* and nitrates along the river ecosystems. The investigation was carried out at the 14 stations of which are located on the river and five on reservoirs.

Measurement of physical, chemical and microbiological properties to identify red points and offer the reclamation methods. For example for high concentration of nitrates in agriculture part of catchment we suggest to make "denitrification wall"/denitrification process and set up phytoremediation work connected with planning wetlands, which can catch nitrates and changes its in denitrification process in N_2. Compare the chemical and microbiological data with hydrological processes (low-water, flood) and try to find the correlation of this process.

Reclamation of river creates new conditions and improves environmental quality of existing green areas what is linked with improvement of human health and development this areas.

Karolina Tomczyk (2008). Vermicomposting of sewage sludge as a method to obtain increase of biomass of the energetic willow on the protected zone of the Wastewater Treatment Plant (WWTP) in Lodz. University of Lodz and European Regional Centre for Ecohydrology u/a UNESCO MSc thesis.

Vermicomposting is becoming a promising way in sewage sludge utilization. The aim of the study:
- evaluation of the nitrogen and phosphorus mineralization during vermicomposting of sewage sludge mixed with waste sawdust in ratio 3:1 (dry weight),
- estimation and comparison of growth and biomass of energetic willow and energetic grass treated with verrmicompost and sewage sludge used as a fertilizers,
- estimation of switch of heavy metals content in vermicompost at the beginning and at the end of process of vermicomposting,
- estimation of heavy metals content in plant tissues;

The experiment consisted of three phases:
- 1° municipal sewage sludge was mixed with poplar sawdust (ratio 1:3 of dry matter) and composted for 45 days. It was watered once a week with distilled water.
- 2° compost was settled with commercially purchased earthworms *Eisenia fetida* and vermicposted for 4 months. It was watered once a week with distilled water.
- 3° plastic containers were filled with ready vermicompost (depleted with earthworms) mixed with commercially purchased soil and and planted with cuttings of 3-yeras old willow tress *Salix viminalis* obtained from University of Łódź Tresta Field Station. The containers were dug on the plot in Tresta Field Station. The same procedure was applied to plain sewage sludge: the amount of sewage sludge was calculated so as the amount of heavy metals contained in 1kg of mixed vermicopost/sewage sludge + soil was the same. During the course of the experiment the mesocosms were weeded, and also watered in dry periods. This mesocosm experiment lasted for 4 months when willow were cut and dried.

Results:
Willow trees fertilized with vermicompost obtained 30% bigger yield (roots, shoots and leaves) compared to those grown on plain sewage. (Fig. 2). Bigger yield of willow tress fertilized with vermicompost may be a result of enhanced microbial activity caused by earthworm excrements.
The research contributed to the SWITCH demonstration project on the willow plantation on the WWTP in Lodz.

Maciej Olejniczak (2008). Defining relationship between plant cover and ground waters as a key for identification of rehabilitation hot-spots in an urban river valley. University of Lodz and European Regional Centre for Ecohydrology u/a UNESCO MSc thesis.

The focus of the project is to define a relationship between existing vegetation and ground water quality and quantity. Vegetation changes and dominant species composition along the Sokolowka river is to be an indicator of river – valley connectivity and harshness of environmental conditions (including anthropogenic pressure). Additionally, the continuous measurements of changes in water level and nutrient load to ground waters are carried in the most representative plant communities. Compared with meteorological data and river discharges, they are to be used for generating information about current buffering role of plant zones and possibilities to increase their efficiency by implementation of environmental technologies and engineering. Defining plant-water interplay along 6 chosen transects will be also helpful in identification of river sections that should be considered under restoration scheme due to high regulatory potential of plant cover and high naturalness and/or value of valley vegetation.

To meet the aims, following tasks have been planned:
1. establishing of piezometer transects plant communities best representing the valley vegetation;
2. monitoring of ground water level and nutrient load to ground waters;
3. complete characteristics of valley vegetation, with respect to dominant species and indicatory species;
4. estimation of plant biomass along transects;
5. identify relationships between dynamics of hydrological, hydrochemical and meteorological parameters;
6. combine obtained data with information on land covers and vegetation;
7. generalize outcomes for the river valleys indicating areas important for rehabilitation of river and its surroundings and revitalization of the whole area.

Bartłomiej Wojtyra (2008). Energetic willow as an instrument for sustainable development implementation. University of Lodz and European Regional Centre for Ecohydrology u/a UNESCO MSc thesis.

The aim of the study:
- Estimation of the increase of biomass of the energetic willow in the different conditions.
- Estimation of the toxicity of soil after use of the dose sewage sludge in the environmental and experimental conditions (Phytotoxkit Tigret);

Methodology:
On every experimental field 7 shrubs have been chosen. Every shrub has been measured of his increase of length every month. Measurements of soil have focused on humidity, metabolism changes, organic matter content and toxicity.

Results:
The biomass of the willow was dependent on the herbaceous plants. The low biomass of plant created good soil condition, but high biomass reduced the yield of willows biomass.
The research contributed to the SWITCH demonstration project on the willow plantation on the WWTP in Lodz.

Paweł Kożuchowski (2008). Hydromorphological evaluation of water courses and river bed retention of streams in Sokolowka catchment. University of Lodz MSc thesis.

Channelization reduces water retentiveness in the landscape and hydrological capacity of streams. Nowadays, a large part of the Sokolowka river is regulated by concrete slabs. It is also being straightened and deepened.

The dissertation will focus on two main issues. One of them is a hydromorphological evaluation of Sokolowka and Brzoza (tributary of Sokolowka) rivers, made with the use of RHS (River Habitat Survey) method. The main objective is to estimate an environmental transformation of the Sokolowka valley. The spatial diversity of environmental transformation will be also evaluated. Obtained information might be helpful in the future river catchment management.

The second one is measurement of the river bed retention of all streams in the Sokolowka catchment. This will enable the estimation of both actual and maximal retention. The results might be applied to future search of flood hazard reaches.

Anna Durys (2008). Land use and impermeability of ground in urban areas (the Sokolowka catchment case study. University of Lodz MSc thesis.

It is obvious that impervious surface increase determines a rise of stormwater peaks in streams. The Sokolowka river, located in the northern part of Lodz, is a typical urban storm water drain. The large part of its catchment is covered by impermeable surfaces. However, its western part is occupied by outskirts, where artificial surfaces are rather small.

The main objective of this dissertation is to estimate an impact of land use on a structure and a size of rainwater run-off. Selected characteristics of land use will be counted and presented on maps. This work might be used as a background for general analysis of the Sokolowka catchment. It might also help to gain greater knowledge and understanding of water circulation peculiarities in urban and sewerage catchments.

Anna Durys has been granted a special scholarship by the Mayor of the City of Lodz in order to be able to conduct any activities necessary for the completion of the above dissertation.

Piotr Kujawski (2008). Water supply and sewage disposal in the Sokolowka catchment. University of Lodz MSc thesis.

This dissertation will present the results of the research conducted within the borders of the City of Lodz, within Sokolowka catchment, as far as the Zimna Woda tributary.

Sokolowka is one of the smallest rivers in Lodz. It is situated far from the city centre where the textile industry had developed. These are the reasons why it has not been considerably transformed like other rivers of Lodz – Lodka or Balutka. Only in the 1970s, when the housing estate Radogoszcz – Zachod was built, it was decided to conduct drainage works on one of the river parts. It led to the destruction of main boggy areas which once served as the natural storage for an excess of water.

The aims of this dissertation can be grouped in two areas. One of them includes a completion of the research of the quality and amount of underground waters, by means of conducting measurements in over one hundred walls within the basin area.

The next stage is to analyze the spatial range of sanitary and storm drainage, as well as water supply, and determine the divides of running water and drainage. The directions of waste draining and areas that are, or may be, sources of impurities will also be established. It will be attempted to determine how much water is provided to the Sokolowka basin, from outside of its area, by water supply.

Katarzyna Nowak (2009). Benthic diatoms used to assessment of water quality of the Sokołówka River. University of Lodz MSc thesis.

The aim of this research was to present qualitative and quantitative analysis of the benthic diatom from 8 stations of the SWITCH project, located on the following sections of the river. Basing on the indicative properties of benthic diatom taxa, ecological status assessment has also been made.
This study presents the results of two years' research taken in 2007 and 2008. During the research, 173 diatom taxa was identified. Diatom indices of trophy and saprobity, such as TDI, GDI, IPS, EPI-D, and percentage of species tolerant to pollution, indicates that water conditions in the examined section were: hypertrophic to eutrophic and from α-mesopolysaprobic to α-mesosaprobic.
The research contributed to the SWITCH demonstration project on the Sokolowka River.

Paulina Nowicka (2009). Benthic diatoms of reservoirs on the Sokolowka River. University of Lodz MSc thesis.

This study presents the results of two years' of research - 2007 and 2008. The aim of this study was to make the qualitative and quantitative analysis of the communities of the benthic diatoms, collected from 5 reservoirs and the cascade of the Sokolowka river. Based on the indicatory value of the diatom taxa, which was identified, ecological status assessment of this reservoir has been made. According to the indices of trophy - TDI, percentage of species tolerant to pollution, and Hoffmann classification, reservoirs were highly eutrophic. Saprobity indices – IPS and GDI - indicate that water conditions of reservoirs were β-mesosaprobic to polysaprobic.
The research contributed to the SWITCH demonstration project on the Sokolowka River.

Renata Włodarczyk (2010). Drivers and pressures of city water resources – developing risk-based decision support system for implementation of Ecohydrology approach. University of Lodz and European Regional Centre for Ecohydrology u/a UNESCO MSc thesis.

The research was to reveal the perceptions of decision makers related with factors influencing water resources in the City of Lodz and emerging risks. The assumption was that perceptions and understanding of risk profiles of different drivers influence the decision making process. The survey was conducted among the members of Lodz Learning Alliance responsible directly and indirectly for water management in the city.

The aim of the study comprised:
- identification and prioritization of socio-economic drivers that can affect the water resources in the City of Lodz,
- defining the risk to the environment and water resources in the city, using DAPSET - Drivers and Pressures – Strength Evaluation Tool- (online tool, initiated under FP6 NoE AlterNet project (GOCE-CT-2003-505298))
- developing recommendations for sustainable resources management.

The study confirmed usefulness of DAPSET model for identification and prioritization of socio-economic drivers and pressures affecting the environment and water resources in the city. It was also helpful in defining the problematic aspects of chosen factors and further focusing of actions. Elaboration of risk profiles for: land use changes, public awareness, economic status of the city, effectiveness of law execution had an impact on the quality of debate about city action plan related to environment and life quality. It also facilitated the transfer of knowledge between practitioners (city officers) and researchers, and thus helped in defining the topics for demand driven science.

Małgorzata Zasępa (2011). The city gardens as a potential component of the Blue-Green Network – influence of people's attitudes on quality of environment. University of Lodz and European Regional Centre for Ecohydrology u/a UNESCO MSc thesis.

The study includes mind mapping of the socio-economic factors influencing the city gardens, and their role in flow of energy and matter, and the survey linking the attitudes of the garden owners with management practices. The data were collected in three complexes of urban gardens located within river valleys in different parts of Lodz. Additionally to elaborate a reference data for water quality in respective rivers, the garden inflow-outflow water quality analysis was conducted in 6 subsequent months starting from April 2010.

The aims of the study included:
1. Analysis of seasonal impact of city gardens on water quality of three rivers: Jasien, Balutka and Olechowka
2. Analysis of influence of life philosophy and system of values of garden owners on their land use practices and their possible environmental impact
3. Defining what are trends in garden use are and what their future impact can be.
4. Analysis of the role of urban gardens in the Blue-Green Network and ecological system of the city
5. Increasing environmental awareness of inhabitants of the City of Lodz

The preliminary results indicate that the owners of the gardens represent a group homogenous in terms of education and professional position. They declare to be ecocentric and consider the area of city greens as too small. According to interviews the services provided by their gardens mostly include: contact with nature, food production, a meeting place with friends. However the comparative analysis of chemistry of water entering and leaving the gardens indicates significant increase in concentration of: nitrates, nitrites, and phosphates. In early spring also concentrations of ions of sodium, potassium and magnesium are higher in the outflow than in the inflow to the gardens.

A. DROBNIEWSKA (2008). OPTYMALIZACJA WYKORZYSTANIA OSADU ŚCIEKOWEGO DO PRODUKCJI BIOENERGII NA PODSTAWIE WIELKOSKALOWYCH EKSPERYMENTÓW TERENOWYCH ORAZ MODELU MATEMATYCZNEGO. PhD thesis, University of Lodz.

Abstract not available

M. URBANIAK (2009). ANALIZA PORÓWNAWCZA ZAWARTOŚCI DIOKSYN I ZWIĄZKÓW DIOKSYNOPODOBNYCH W ZBIORNIKACH ZAPOROWYCH O RÓŻNYCH FORMACH ANTROPOPRESJI. PhD thesis, University of Lodz.

Abstract not available

Martin Brian Hendrie (2009). Assessing vertical water flux between groundwater and surface water at the River Tame Hyporheic Zone SWITCH Test Site using temperature time series. University of Birmingham MSc thesis.

Implementation of recent legislation coupled with the potential attenuation of contaminants in the groundwater-surface water exchange zone has sparked a global push to further our understanding of the complex geochemical, biological and hydrological processes occurring within the hyporheic corridor. Temperature time series analysis has been used increasingly to characterise water movement between rivers and groundwater. In this study temperature time series data collected from a multilevel temperature probe installed at the SWITCH (Sustainable Water Management Improves Tomorrow's Cities Health) Hyporheic Zone (HZ) test site, Birmingham, has been used to examine the vertical movement of water between the River Tame and the underlying hyporheic sediments. A method of temperature time series analysis was developed using a thermal analogue of the Ogata-Banks solution (1961) to the one dimensional advection dispersion equation for solute transport. Visual Basic (VB) language was used to write a simple program which solves the modified Ogata-Banks solution and uses superposition of step functions to simulate temperature signatures at selected depths. Vertical flux estimates obtained from this method were comparable to average flux values obtained from numerical modelling of the riverbed using the software package VS2DI, and Darcy based flux estimates. It is proposed that this semi-analytical method provides a simple and easy to apply method of temperature time series analysis, providing averaged estimates of vertical flux and thermal properties.

Simon Shepherd (2009). Hydraulic controls on water quality variations: The River Tame Hyporheic zone SWITCH urban test site. University of Birmingham MSc thesis.

This study investigates the hydraulic control of riverbed materials on water quality variations within the Hyporheic Zone, in the area where groundwater and surface water interact. The study site is the SWITCH Urban Hyporheic Zone Test Site on the River Tame which was set up to research how to reduce risks from contaminated groundwater entering streams and rivers, and thereby increase sustainable water management. Previous studies have shown the Hyporheic Zone to be complex, with considerable heterogeneity within stream bed materials which result in highly heterogeneous permeabilities. Four transects of the river were studied close to existing piezometers and a borehole where hydraulic and water quality conditions could be monitored. Chloride (CL-) and Nitrate (NO3-) levels were analysed to represent sources from surface water and groundwater respectively. Freeze coring was used to collect intact material from the riverbed to enable sediment and hydraulic conductivity analysis to be more accurate. The results show Nitrate levels increase with depth, whereas Chloride levels fall and the patterns are less complicated through the homogenous sand. However there is some doubt over the validity of the data as several profile anomalies were recorded on site.

Despite there being positive flows from the aquifer to the river the chemical profiles indicate there is mixing taking place within the riverbed.

Results show the increased permeability of riverbed sediments can lead to nitrate reaching the river with concentrations not having been significantly reduced. Despite it not being concluded, there is some evidence for denitrification within the hyporheic zone.

The data and information provided from the various methods used only allow for a limited heterogeneity to be considered and therefore the conclusions provided reflect this

Jennifer Laura Whelan (2007). HYPHOREIC ZONE HYDRAULIC TESTING: RIVER TAME, BIRMINGHAM. University of Birmingham MSc thesis.

The hyporheic zone is a dynamic ecotone, within which important physical, chemical and biological processes occur. It is believed that the hyporheic zone has the potential to naturally attenuate contaminants and limit their exchange between groundwater and surface waters. Fieldwork was conducted on an urbanised stretch of the River Tame in north Birmingham in order to characterise the hydraulic properties of the unconfined sandstone aquifer and river bed sediments. The hydraulic conductivity of the Kidderminster Sandstone was calculated as 2 m/d. Groundwater head measurements indicated that the Tame was gaining along the entire study reach with a mean hydraulic gradient of 0.1036. The river bed sediments were found to be very heterogeneous with their hydraulic conductivities ranging from 0.61 m/d to 52.96 m/d, the mean hydraulic conductivity is 5.28 m/d. Groundwater flow modeling of a proposed pump test next to the river indicated that pumping at a rate of 200 m3/d will reduce the observed hydraulic gradients by between 2.07% and 48.51%, this is very much dependent on the hydraulic parameters for the river bed sediments, and to a lesser extent, the superficial drift deposits.

Derek John Conran (2006). ASSESSMENT OF GROUNDWATER-SURFACE WATER MIXING ZONE TRANSIENTS: BIRMINGHAM-RIVER TAME STUDY. University of Birmingham MSc thesis.

Abstract not available

Conor Lydon (2006). Design for the Hyporheic Zone Dipole Setup. University of Birmingham MSc thesis.

The hyporheic zone has been a much studied area of hydrogeology for a number of years. A research experiment is proposed over the coming years, which will allow the hyporheic mixing zone to be assessed through the use of chemical tracers. An artificial hydraulic gradient is required to generate a downward gradient that will generate a mixing zone within the riverbed sediments.

This work has developed a „Dipole‟ well design that included abstracting and injecting groundwater adjacent to a stretch of river; thus generating the conditions that will facilitate the future experimental research. Optimum well positioning and operation were found to be the keys to the success of the future research.

A complete characterisation of the proposed river section was conducted that allowed the development of a numerical model using Modflow, to simulate the likely affects to the aquifer and river systems, by implementing such a well design.

Discharge rates of $1 - 4$ ls-1 were required to generate flow reversals within a typically gaining section of river, for wells positioned at $30 - 50$ m spacing.

The success of the research experiment will depend on the accurate implementation of the well design. Many of the problems associated with applying the Dipole experiment are explored in this study.