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ABSTRACTS
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Lakes and Reservoirs – Sandwiched between the catchment and the treatment plant

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Lakes and Reservoirs present an interesting dilemma. On one hand they attenuate risk and on the other they propagate risk. Managing the risk relies on understanding where the hazards are and how they are transported from the catchment, where they emerge in the reservoir and what the implications are for water treatment. Hydrodynamics play a key role in the generation and transport of hazards. Rainfall-inflow events transport nutrients, DOC and pathogens from the catchment. The timescale at which these become problematic depends upon the size of the reservoir and the prevailing hydrodynamics. Nutrients may remain unused until conditions are right for algal growth, pathogens may present an immediate risk, and DOC can be both a long-term and an immediate challenge for disinfection byproduct formation and selecting the right alum dose. Knowing where the hazards are, extracting water appropriately and understanding what threat there is to treatment can improve water quality, reduce disinfection byproduct formation and lead to considerable cost savings.
Long term phytoplankton datasets: to trust or not to trust?

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In my presentation I will discuss 4 recent papers (see references). The first paper seeks to explain the observation of a strong increase in phytoplankton diversity in Lake Zurich, Switzerland since the mid-1970s. The accrual is observed at different taxonomic levels as well as at the functional trait level. The authors hypothesize that this accrual can be explained through an interaction between re-oligotrophication and climate warming. These processes created a lake environment which has become physically more stable and chemically more heterogeneous, allowing a larger degree of phytoplankton co-existence. Communities at different depths in these deep alpine lakes are now more dissimilar than 2 – 3 decades ago. Straile et al. (1) raised a number of comments against the Pomati et al. (2012) paper. They argue that the perceived increase in diversity is likely to be an artifact, resulting from a steadily improving expertise by the staff counting the Lake Zurich phytoplankton. Straile et al. (2013) moreover argue that temporal synchrony between phytoplankton changes in mesotrophic Lake Zurich and nearby oligotrophic Lake Walen provides a strong argument in favor of misclassification. In return Pomati et al. (2015), while acknowledging some of the comments by Straile et al. (2013), maintain that the biodiversity accrual is real, and the perceived artifacts cannot explain the patterns in Lake Zurich phytoplankton. Rather a regional coherence between phytoplankton communities may signify real underlying ecological processes. In a recent reply Straile et al raise more objections, including the observed step change increases in biodiversity. Also this will be discussed. There may not be a definitive answer to the question whether we can trust long term phytoplankton datasets, but they are potentially a valuable tool in understanding environmental change, hence the question `to trust or not to trust` should be discussed.

References

1) Effects of re-oligotrophication and climate warming on plankton richness and community stability in a deep mesotrophic lake, published by Pomati, Matthews, Jokela, Schildknecht & Ibelings (Oikos, 2012).
Remediation of Lakes – Natural and Man-Made

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I will attempt to describe an eclectic mix of remediation strategies for lakes primarily located in Canada, including: the oxygenation of the north basin of Amisk Lake (Lawrence et al. 1997), together with an explanation of the “unexpected leakage” into the south basin; the design of a diffuser to inject supersaturated water from a Speece Cone into the hypolimnion of Newman Lake (Moore et al. 2012); the rapid artificial circulation of Colomac Zone 2 Pit-lake (Pieters et al. 2015) to remove cyanide and ammonia; the use of a solar-powered circulation device to maintain an ice-free patch to prevent winterkill in Menzies Lake (Rogers et al. 1996); the application of ammonium phosphate to the epilimnia of Kootenay and Arrow Lakes (Stevens et al. 2004) to stimulate productivity and to halt a precipitous decline in endangered salmon populations; the siting of a prospective selective withdrawal intake in Coquitlam Reservoir to minimize turbidity; the hypolimnetic withdrawal of phosphorus laden water from a dredged hole in Chain Lake (Macdonald et al. 2004), together with replenishment with fresh water diverted from a nearby creek, to control eutrophication; the impact of internal wave damping in an unlogged reservoir on the reliability of a low level cold water release from the Nechako Reservoir (Imam et al. 2013); and the impact of reservoir operations on productivity in Kinbasket and Revelstoke Reservoirs (Pieters & Lawrence, 2012).

Modeling the Impact of Oxidants on Cyanobacteria in Water: Cell Lysis and Odorant and Cyanotoxin Degradation

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Occurrence of cyanobacteria has become a serious environmental phenomenon and threat to water resources on a global scale due to human activities coupled with underlying climate change. Excessive proliferation of cyanobacteria in drinking water sources may diminish the aesthetic value of the water, pose potential health risks to humans and impact the ecosystem. Hydrogen peroxide is a common and widely used chemical for disinfection and water treatment, and has recently been proposed as a potentially environmentally benign algaecide. However, the effect of H2O2 on cell integrity and the release of metabolites needs to be better understood. In this study, the oxidant effect of H2O2 under controlled light conditions was first evaluated using a microcystin-producing cyanobacterium, \textit{M. aeruginosa}, as the model species. The production of OH radical, the loss of cell integrity, and the release and degradation of MCs in a H2O2/cyanobacteria system was then quantified. Finally, sequential reaction models were developed to quantitatively describe the kinetics of cell rupture and simultaneous MC degradation in the presence of H2O2. The models successfully predicted the concentration change of MCs using independently measured parameters. The sequential models were also successfully extrapolated to predict the concentration changes of MCs in \textit{M. aeruginosa}-laden water in two different oxidation systems, titanium dioxide/H2O2 and ferrate. These models provide a simple and quantitative means to estimate the interaction of oxidants and cells and the consequent release of metabolites during oxidation treatment of cyanobacterium-laden waters.
Mixing Dynamics in Lakes and Reservoirs

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Anoxia often develops in the lower water column of lakes and reservoirs by degradation of organic matter. Greenhouse gases then accumulate, and vertical mixing of nutrients produced by remineralization causes algal blooms. Fish farming is now being introduced in a number of reservoirs in order to provide needed protein and its effects on water quality need to be determined to improve management. Internal waves are ubiquitous features in stratified fluids, and the mixing or horizontal transports associated with them may ventilate the lower water column. Mixed layer deepening in part depends on evaporation rates which vary by latitude. Anoxia may be reduced if oxygenated inflows are negatively buoyant. In this talk, I will use case studies from a number of lakes and reservoirs to illustrate controls on hydrodynamics at different latitudes and resulting effects on accumulation of phytoplankton, persistence of anoxia and fluxes of greenhouse gases, current challenges in modelling the influence of internal waves, and applicability of dimensionless indices in predicting extent of stratification and resulting water quality.
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Prediction of algal competition and odor occurrence in a drinking water reservoir impacted by the South-to-North water diversion based on ecological model

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The prediction of odor-producing Planktothrix was performed based on ecological niche theory and redundancy analysis in Miyun Reservoir, in case of accepting Danjiangkou water with higher TN. The result shows the growth potential of the Planktothrix will increase according to the simulation result.

Witnessing the environmental impact on the Chilka Lake in India

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The Chilka Lake is directly effected by the change in climate in India leading to serious environmental impact to the coastal as well as affecting the human life and local occupation.
Integrating 3D hydrodynamic modelling into decision support systems in a large water utility

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Melbourne Water is a large wholesale water utility located in south-eastern Australia, supplying drinking water to over 4 million customers. The water supply is mostly unfiltered due to protected catchments and large storages. To manage and maintain the unfiltered nature of the supply a detailed understanding of the risks to water quality and how to address potential changes in water quality is essential.

A part of Melbourne Water’s water quality management strategy has been to build hydrodynamic models of all of their major drinking water reservoirs. This strategy has included the installation of sophisticated monitoring equipment, the development of a software based real-time decision support system and a significant investment in staff education and training. This approach has been invaluable in terms of assisting with decision making across different facets of Melbourne Water’s business. This paper looks at 3 different case studies where real-time data and modelling as well as scenario analysis have been used by in-house modelers to aid in major engineering and water quality decisions. Specifically the case studies will look at how models have been used to; inform capital investment, optimize existing infrastructure and respond to and manage incidents.

The model simulation results have provided knowledge about where best to locate a new water source reservoir inlet and the effect on water quality of that water. They have led to an avoidance of unnecessary spending on a new aerator and assisted in the operation of the existing aerator. Model outputs have also prevented a major water quality incident being declared.

Melbourne Water’s approach to modelling and its integration into decision making has proved to be a fast, effective and highly valuable tool, saving money and time while maintaining the company’s reputation for the supply of high quality drinking water.
Ignored Sediment Fungal Populations in Drinking Water Reservoirs Are Revealed by Quantitative PCR and 454 Pyrosequencing

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The sediment hosts a variety of fungal species in water supply reservoirs; however, the taxonomically and functionally diverse fungal populations have remained vastly unexplored. Here, quantitative PCR and recently developed 454 pyrosequencing were combined to investigate the abundance and diversity of sediment fungal communities in reservoirs. These results revealed 1991, 2473, and 2610 copies of the 18S rRNA gene in the sediments from the ZC, SBY, and JP reservoirs, respectively. The fungal abundance in JP reservoir was 1.31 times higher than that of the ZC reservoir. In general, 43123 reads were recovered, corresponding to 945 distinct molecular operational taxonomic units. The majority of the fungal nuclear ribosomal internal transcribed spacer region sequences were affiliated with Ascomycota, Chytridiomycota, Basidiomycota, Glomeromycota, and Mucoromycotina. The highest Chao 1 index (962) was observed in the JP reservoir, and this value was 5.66 times greater than that of the SBY reservoir. Heat map analysis showed that Rhizophydium (relative frequency 30.98%), Placidium (20.20%), Apophysomyces (8.43%), Allomyces (6.26%), and Rhodotorula (6.01%) were the dominant genera in the JP reservoir, while Elaphomyces (20.0%) was the dominant genus in the ZC reservoir and Rhizophydium (30.98%) and Mattirolomyces (39.40%) were the most abundant in the JP and SBY reservoirs. Glomus sp. was only found in the JP reservoir. Furthermore, the larger proportions of “unassigned fungi” call for crafting International Nucleotide Sequence Database. Principle component analysis and network analysis also suggested that tremendously diverse functional fungal populations were resident in the sediments of the three water supply reservoirs. These findings will undoubtedly broaden our understanding of reservoir sediment fungal species harbored in this freshwater stressful environmental condition. Future research should be conducted to determine the potential for fungi to degrade complex pollutants and their secondary metabolites related to the water quality.
Effects of oxygenated water supply by WEP system to the hypolimnion in Sanbe Reservoir, Japan

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Hypolimnestic anoxia in summer is often observed in lakes and reservoirs. To cope with this problem, hypolimnetic aeration/oxygenation is becoming a common management technique. We performed a series of field experiments in Sanbe Reservoir, a Japanese drinking water and flood protection reservoir using a hypolimnetic oxygenator called Water Environmental Preservation System (WEP) from April 2006 to December 2009. This system consists of a source of pure oxygen gas, a cylindrical contact chamber and a submersible pump. Highly oxygenated water is axisymmetrically dispersed into the hypolimnetic water directly from a chamber. The injection depth was adjusted to match the level of low oxygen concentrations in the reservoir by changing the wire length of the chamber.

We succeeded to oxygenate all hypolimnetic water in summer. The field data showed that the intrusion of oxygenated water from the device traveled more than 800 m horizontally to the far end of the reservoir in 4 weeks at approximately the same height of the outflow opening of the device. The speed and the thickness of the intrusion decreased with distance.

During the experiments, we sampled waters at 1 m up from the bottom and some other depths at several locations in the reservoir. The time series of water quality showed NH4-N, PO4-P, total and soluble Fe and As decreased remarkably during the WEP operation but a soluble Mn did not show a clear decrease.

We also measured ORP of pore water in the bottom sediment. We defined oxygenated sediment layer as the layer shows positive ORP. The oxygenated sediment layer was up to 16 mm and it became thicker than 10 mm when the DO at 0.5 m up from the bottom was more than 15 mg/L, which might suppress the elution of the in-organic nutrients and soluble metals.
SIMULTANEOUS NITRATE AND PERCHLORATE REDUCTION IN MIXOTROPHIC REACTOR

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Perchlorate is a persistent inorganic pollutant often used in its salt form. It has been used as an oxidizer in rocket propellants, explosives, road flares and airbags. It is also found in some fertilizers together with nitrate and commonly found in groundwater together with nitrate. Perchlorate competitively inhibits the iodine uptake by the thyroid which results in a decrease in thyroid hormones. Perchlorate concentrations in drinking water sources are relatively low in µg/L range and it is difficult to add the exact amount of single organic electron donor to reduce mg range nitrate and µg range perchlorate. Partly autotrophic reduction of these oxyanions may overcome the organic contamination risk; it also provides the satisfying sulfate and alkalinity concentrations in the effluent. There are few studies on sulfur-based mixotrophic denitrification processes for the drinking water treatment. In this study, the biological reduction of nitrate and perchlorate was investigated in a mixotrophic bioreactor using elemental sulfur and methanol as the carbon source. The reactor was supplemented with methanol at CH3OH/NO3--N ratio of 1 or 1.4. Influent perchlorate was completely removed up to 1000 µg/L. Complete reduction of 25 mg NO3--N/L was achieved, corresponding to a maximum nitrate reduction rate of 400 mg NO3--N/(L.d). The effluent sulfate concentration was controlled by adjusting C/N ratio in the influent. In the study, mixotrophic denitrification was stimulated by 25 mg/L methanol addition and 53% of influent nitrate was reduced by heterotrophic process, which decreased the effluent sulfate concentration to half of the autotrophic counterpart. Therefore, mixotrophic process may be preferred when effluent sulfate concentration is of concern and the higher perchlorate reduction efficiency is desired.

Keywords: Perchlorate reduction, mixotrophic process, denitrification, nitrate reduction
The use of Macrophyte Treatment Systems for Water Quality Improvement in Singapore

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Since the launch of the Active, Beautiful, Clean Waters (ABC Waters) Programme in April 2006, PUB, Singapore’s national water agency, has implemented natural green treatment features in urbanised water catchments to detain and treat surface runoff closer to source before water flows into adjacent waterways and discharges into reservoirs. These features include rain gardens, bio-retention systems, bioswales, constructed and floating wetland systems.

This paper describes Singapore’s experience with a variety of macrophyte treatment systems. Currently, there are 7 constructed wetlands, 25 rain gardens and 5 bioretention swales. The systems implemented to date are generally small, serving multiple functions of improving water quality, aesthetics and wildlife habitat. PUB continues to improve water quality on the catchment-scale through the placement of such small-scale treatment units in strategic locations to intercept nutrient loading from both diffuse and point sources in agricultural, industrial and residential areas. The biotope at Bishan-Ang Mo Kio park is one example that has shown promising results.

PUB also uses macrophytes to enhance reservoir water quality management. Growth of rooted emergents such as Eleocharis, Polygonum, Ludwigia along reservoir earth banks is encouraged. Optimal harvesting practices of submergents which have colonised shallow areas in reservoirs have also helped to maintain good reservoir water quality. However, many reservoirs have characteristics unfavourable to macrophyte establishment such as great depths and concretized embankments, which limit submergents and emergents. Macrophyte restoration in these reservoirs is being planned and will be explored through the use of a variety of plant types via different establishment methods. Additionally, enhanced macrophyte treatment units are being piloted in canals and at reservoir inflows to reduce nutrient-loading into the reservoirs. The maintenance of these systems in concretized canals with high stormwater flows from urbanised catchments remains a challenge.
Aeration to Hybrid Oxygenation; Advancing Water Quality Management Strategies in Three Water-supply Reservoirs at the Western Virginia Water Authority

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The Western Virginia Water Authority (WVWA), in Roanoke, VA manages several water-supply reservoirs for the City of Roanoke and surrounding counties. Each reservoir is unique, Spring Hollow being deep Zmax~62m, Carvins Cove being shallower Zmax~20m, and Falling Creek being shallow Zmax~9m, but all share water quality challenges, similar to other systems across the U.S. and around the world. Common water quality challenges arise from eutrophication, such as prolonged anoxia in bottom waters resulting in the release of soluble compounds from the sediment to the bulk water and increased algae issues, predominantly blue-green blooms throughout the year. Several water quality management strategies are available as resources to combat eutrophication and address water quality, such as line-diffusers, air-lift aerators, and saturation technology. The WVWA first implemented line-diffuser aeration in Spring Hollow in 1997. Since then, the WVWA has upgraded the Spring Hollow diffuser to use pure oxygen and installed other line-diffuser systems; one in Carvins Cove in 2005 and a hybrid oxygenation combined with aeration in Falling Creek in 2013. Through several years of collecting high resolution discrete depth profiles combined with bubble-plume modeling, each water quality management strategy implemented built upon the knowledge gained from prior installation and operational experience. Results include sustained dissolved oxygen in the hypolimnion in excess of 7 mg/l, delisting from the EPA 303d list for impaired water bodies, dramatic decreased concentrations of soluble metals, specifically manganese, and rapid dissolved oxygen recovery following periods when oxygenation was shut down. The building block of knowledge from Spring Hollow aeration in 1997 to the hybrid installation in Falling Creek in 2013 will be presented, showing the advancement of operational strategies, system design, and long-term operation of the systems operated by the WVWA.
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Character and classification of Ajay River water through index analysis and chemometrics

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Ajay River is an important river of the state of Jharkhand and West Bengal, India. The extent of physico-chemical parameters in the Ajay River has been assessed. Water samples were collected at seven strategic locations along the river system. The objectives of the present study were to prepare water quality index (WQI), Agglomerative hierarchical cluster analysis (AHCA), Principal Component analysis (PCA), Salinity index (SI) for the Ajay River and to evolve the sources of water pollution. Various parameter including pH, Temp, DO, EC, TDS, Ca2+, Mg2+, NH4+, Na+, K+, F-, Cl-, NO2-, Br, NO3- and SO42- were analyzed (APHA 2005) during pre-monsoon season to determine the water quality of Ajay river. During investigation most of the parameters were found to be within the permissible limits of prescribed standards except DO and NO2-. DO values were less than the regulatory standard (≥ 6.0 mg/l) which indicates that the river water is not well oxygenated throughout the year at these locations. WQI classified river water into good and medium reflecting the water to be ecologically suitable and sustainable. In the PCA analysis eigen values of the first five principal components have been found more than one, so it can be used to assess the dominant hydro-geochemical processes. In the PC 1 high positive loading of Na+ and K+ ion reflects ion exchange on the clay materials and the process of dissolution of Na+ and Cl- suggest a higher rate of weathering. Salinity index (SAR and % Na) display the river water was suitable for agriculture. Correlation coefficients were calculated between different parameters to identify the highly correlated and interrelated water quality parameters. The river water was found to be ecologically suitable and sustainable because of absence of any major anthropogenic influence in the region.

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Water Quality Variations and Storm Runoff Impacts on Jinpen Reservoir, in Northwest China

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This paper introduces the seasonal variation characteristics of water quality and the impacts of different rainfall runoffs on Jinpen Reservoir. Coping measures of the water problems due to seasonal variation and runoffs are also discussed in this paper. Weekly water monitoring results indicated that during the stable stratification period the maximum concentrations of total nitrogen, total phosphorus, ammonia, total organic carbon, iron and manganese reached 2.5 mg/L, 0.12 mg/L, 0.52 mg/L, 3.5 mg/L, 0.97 mg/L and 0.34 mg/L, respectively. The reason is the release of the sediment under anaerobic condition. As for different amounts of rainfalls, the results indicated that only storm runoff could invade the main reservoir and deteriorated the water quality seriously. During the storm runoffs, the stratification of the reservoir was destroyed; and the reservoir water was deteriorated by high turbidity runoff with particulate phosphorus and organic matters. The concentrations of turbidity, total phosphorus and total organic carbon increased to 256 NTU, 0.224 mg/L and 3.9 mg/L, respectively. So both in stratified and storm runoff period, effective measures that discussed in the end of the paper should be taken to make sure that the water supplied to water treatment plants was with low turbidity and high quality. Adjusting the height of the intake and destroying water stratification by using water lifting aerator are effective methods for seasonal variation characteristics of water quality. And for the storm runoffs, storing the clear water and releasing the turbid, draw-down flushing and dredging and preventing the soil erosion of the upstream area and the surrounding environment are included in the effective methods.
Nutrient release from reservoir sediments impacted by a legacy of historical agriculture practices

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Old, small eutrophic reservoirs accumulate and store a substantial quantity of nutrients and metals in their sediments. The main determinant of whether these nutrients and metals become permanently buried in sediments or whether they are recycled back into the water column is the dissolved oxygen (DO) concentration in the reservoir’s hypolimnion. Low DO conditions trigger internal recycling from the sediments, thereby altering the biogeochemical cycling in the reservoir. Here, we report the results of a whole-ecosystem experiment in which we manipulated hypoxia by sequentially injecting supersaturated concentrations of oxygen into the hypolimnion of Falling Creek Reservoir (FCR) (Vinton, Virginia, USA). FCR is a small, eutrophic drinking water reservoir with a legacy of agriculture in its catchment. Throughout the experiment, we calculated internal and external loads of nutrients and metals. We also collected sediment cores during oxic and hypoxic conditions and manipulated core redox conditions in laboratory incubations to measure potential loading rates of nutrients and metals from the reservoir’s 117-year-old sediments. Throughout our experiment, we were able to successfully manipulate oxic (~12 mg/L) and hypoxic (<2 mg/L) hypolimnetic conditions sequentially for ~4 week periods. Oxic conditions in the hypolimnion successfully suppressed the release of ammonium, phosphorus, and iron from the sediments for a majority of the stratified period. The sediment core experiments were used to determine the maximum potential nutrient release rates from the reservoir’s sediments and followed similar trends as observed in the whole-ecosystem experiment. From both the whole-ecosystem experiment and laboratory sediment core incubations, we observed that internal loading, not external loading, dominated nutrient fluxes in the reservoir, suggesting that historical agriculture practices from the early 1900s still have a profound effect on today’s reservoir water quality.
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Evaluating efficiency of lake restoration methods based on a 3-dimensional hydrodynamic/water quality model at a large shallow Lake Taihu, China
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Lake Taihu is characterized of huge surface area (2,338 km2), shallowness (mean depth 1.9 m), and increasingly serious water environmental problem in China. It has been seriously polluted with economic growth associating with industrial and agricultural development and increased population around the lake in the past 50 years. It is currently eutrophic/hypertrophic although external loading has been significantly reduced and many restoration activities have been conducted. In order to find a "optimized" solution for preventing the water quality from degradation and meet the water quality level target, we evaluated the efficiency of different potential restoration methods including realistic external loading reduction, sediment dredging (internal loading reduction and sediment resuspension reduction), macrophyte planting and water flushing based on a three-dimensional hydrodynamic/water quality model (ELCOM-CAEDYM). Considering their realistic feasibility, the individual way might not remarkably improve the lake water quality at a time scale of 1 ~ 2 years, but the synthetic effect from combined solutions is much more efficient from the model simulations. We ranked the efficiency of individual and combined methods with consideration on their practical possibility, which provides substantial information for lake ecosystem management.

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Effects of hypolimnetic oxygen addition on mercury bioaccumulation in Twin Lakes, Washington, USA
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Twin Lakes, located on the Confederated Tribes of the Colville Indian Reservation in eastern Washington, USA, include North Twin Lake (NT) and South Twin Lake (ST). The mesotrophic, dimictic lakes are important recreational fishing sites for both warm-water bass and cold-water trout. To improve summertime cold-water habitat for trout in NT, dissolved oxygen (DO) addition to the hypolimnion, using liquid oxygen as an oxygen gas source, started in 2009. This study assessed mercury (Hg) in the water column, zooplankton and fish, and related water quality parameters, in Twin Lakes from 2009 to 2012. Because methylmercury (MeHg) buildup in lake bottom water is commonly associated with hypolimnetic anoxia, hypolimnetic oxygenation was hypothesized to reduce Hg in bottom waters and biota in NT relative to ST. Oxygen addition led to significantly higher DO (mean hypolimnetic DO: 2–8 mg/L versus b1 mg/L) and lower MeHg (peak mean hypolimnetic MeHg: 0.05–0.2 ng/L versus 0.15–0.4 ng/L) in North Twin. In North Twin, years with higher DO (2009 and 2011) exhibited lower MeHg in bottom waters and lower total Hg in zooplankton, inferring a positive linkage between oxygen addition and lower bioaccumulation. However, when comparing between the two lakes, Hg levels were significantly higher in zooplankton (total Hg range: 100–200 versus 50–100 μg/kg dry weight) and trout (spring 2010 stocking cohort of eastern brook trout mean total Hg: 74.9 versus 49.9 μg/kg wet weight) in NT relative to ST. Lower Hg bioaccumulation in ST compared to NT may be related to bloom dilution in chlorophyll-rich bottom waters, a vertical disconnect between the location of zooplankton and MeHg in the water column, and high binding affinity between sulfide and MeHg in bottom waters.
Research on the variation of water quality and the pollution status of sediments of Zhelin Reservoir, in southeast China

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This is the first research paper of Zhelin Reservoir. The pollution status of water quality and sediments as well as the sediment release potential were the main concern of this paper. Monthly water quality monitoring was carried out from April 2013 to April 2014. The reservoir was polluted in both water quality and sediment in some special areas. During the stratification period, high concentrations of pollutants and algal density were observed. The analysis of 9 monitoring points of sediments showed that the concentrations of mercury (Hg) and cadmium (Cd) were at high levels. Through calculating indexes of geoaccumulation and the enrichment factors, a conclusion was obtained that the reservoir sediment were highly polluted by Cd and moderately polluted by Hg. The enrichment factors of Cd and Hg were 16 and 10.4 which indicted severe enrichment. The sediment release experiments showed that the max release concentrations of total nitrogen, total phosphorus, iron, manganese, cadmium, lead and arsenic were 2.68 mg/L, 0.15 mg/L, 4.8 mg/L, 2.7 mg/L, 63.2 μg/L, 32.0 μg/L and 45.2 μg/L, respectively. This research was of great importance on the management of water source pollution control and water supply safety.

The rapid treatment for the algae-bloom water using hydroxyl radicals (•OH) generated from strong ionization discharge

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In recent years, a large number of algae in source water increase the difficulty of the raw water treatment, leading to each index, especially the sensory index, unable to reach the national drinking water standard, after drinking water is treated by conventional treatment process. Meanwhile, released algal toxins seriously threaten to human health.

Using a physical method of strong ionization discharge to accelerate electrons and excitated gas molecules at an atmospheric pressure, O2 or air gases are ionized and dissociated into oxygen activated particles such as O2+, O(1D), O(3P), O3 and so on, and then to be mixed into water with high mass transfer efficiency. The hydroxyl radicals (•OH) are formed by a series of plasma chemical reactions, meanwhile to produce H2O2 and introducing reagent of HO2¯. The time of •OH formation by the high-pressure jet method is only 1s, the total concentration of oxygen free radicals are >20 mg/L, the •OH content is 90 μmol/L as 6~14 times high as that of traditional O3+UV and H2O2+UV method. Algae and pathogenic microorganisms in high algae-laden water are rapidly killed in a large scale by •OH radicals in the process of oxygen activated particles dissolved in the gas-liquid unit. The time of •OH killing algae is only within 0.1ms~6s, the algae concentration is decreased to <10 cells/mL, pathogenic microorganism is under detected limit. At the same time, organic contaminated compound such as algal toxins and odorous substance are rapidly oxidizing degradation into CO2, H2O and inorganic salts, the remaining •OH radicals are decomposed into O2 and H2O, and water quality is purified. The algal toxin is reduced to <1µg/L, and 2-methylisoborneol (2-MIB) and Geosmin (GSM) are decreased to <10ng/L.
Characterization of thermal stratification in a tropical lake using an one-dimensional heat transport model and physical indices

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Thermal stratification in reservoirs occurs mainly by the effect of temperature on water density and one-dimensional heat transport models are widely used to simulate vertical temperature profiles since vertical temperature gradients are dominant in reservoirs. Many applications have been made using one-dimensional models, however, there are still features to be improved to reproduce physical processes or allow for better data analysis.

The article describes an unsteady one-dimensional heat transport model using an implicit finite volume method and including an additional term for enhanced mixing for run of a river like reservoirs with considerable flow rates, thus additional mixing. In addition, the model estimates the following physical indices: temperature gradients, thermocline depth, Wedderburn Number, Lake Number, Brunt-Väisälä frequency and densimetric Froude Number.

The model has been applied to a tropical monomictic lake in South Brazil and showed good agreement with measurements and high temporal resolutions. The additional mixing was estimated by the averaging vertical mixing coefficient for rivers, which improved the results of the one-dimensional heat transport model. A brief analysis of the energy budget allowed for a better understanding of the numerical scheme. In addition simple physical indices based on morphometric data, wind speed and thermal structure of the water column were computed out of the simulated profiles to determine periods when the reservoir stratifies, and how the thermocline varies over time. The results were compared with measured data and the physical indices to identify critical periods in the reservoir.

Effectivity of pressure flushing structures for desilting of non-cohesive sediment in a reservoir: A model study

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Affectivity of the sediment control structure such as radial gates controlled two branch weir under the water intake for hydroelectric power plant was studied at 1/30 geometric scale laboratory model. This weir was designed for washing to settled sediment on the bottom when the flow rate of the river is over capacity of the hydroelectric power plant. Model covers 120 m upstream of the valley from dam axis, spillway which is designed for 4000 m3/s flood discharge by controlled radial gates, hydroelectric power plant intake and sediment washing channel. Two kinds of measurements were performed for determining performance sediment control structure. Firstly, detailed velocity measurements in the upstream part for various flow conditions were achieved. 16 MHz Nortek, Acoustic Doppler Velocimeter was used for determining 3D velocity values, as time series. Velocity measurements were achieved by 3D mesh which is generated since 40 m upstream from axis (in prototype) with at least 64 point at each level. Average velocities also fluctuating part of the velocities were taken consideration as well as Reynolds shear stress for different directions. Secondly, flow visualization experiments were achieved. During the experiments, sediment particles were simulated by polycylen particles by defined shape and size (cylindrical and 3 mm length) with very low specific mass (1.08gr/cm3). During the experiments polycylen particles were spread over sediment control structures intake then flow conditions applied after steady condition washing sediment from upstream was determined. Experiments show that sediment control structures will be effective since nearly 30 m upstream part. Also velocity measurements and calculated shear stress, also Reynolds shear stress measurements supported those finding.
Effective Depth Controls the Nitrate Removal Rates in a Water Supply Reservoir with a High Nitrate Load

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Abstract

The Occoquan Reservoir is part of an indirect potable reuse system where a water reclamation plant (WRP) discharges a nitrified product water to prevent the onset of anaerobic conditions in the bottom sediments during the summer months. The elongated narrow shape of the reservoir combined with water temperature gradients in the inlet results in density currents that enhance the transport of nitrate from the surface to the bottom waters. Nitrate profiles revealed that approximately 80-85% of the nitrate in the inflow migrates to the bottom layers of the reservoir during periods of thermal stratification. The morphology of the reservoir also causes a longitudinal change in the ratio of water volume to sediment area, herein defined as the effective depth (ZED). Field observations revealed that the measured nitrate removal rate coefficients (k) varied inversely with ZED, suggesting that the upper reaches of the reservoir have a higher potential for nitrate removal compared to the areas closer to the dam. A similar relationship between k and ZED was confirmed in laboratory experiments, which were designed and built using ZED as a downscaling modeling parameter. The low variability found between the mass transfer coefficients for nitrate (Coefficient of Variation = 0.25) suggests a nearly constant biotic nitrogen removal along the main body of the reservoir and confirmed that k values were mainly affected by changes in ZED. Finally, similarities in k values between field and laboratory samples with similar ZED values suggest that different segments of natural systems may be properly downscaled to laboratory-sized configurations by means of the ZED concept.

Potable Reuse: Surface Water Augmentation and the California Perspective

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Water is widely recognized as the limiting resource throughout much of California and the western US. This has been brought into sharp focus with the drought over the past several years that has rendered the entire state of California under drought conditions, with vast regions presently under "exceptional drought" conditions and affecting 37 M Californians. A "mega-drought" that could persist for several decades is now recognized as a distinct possibility within this century. Climate change promises to further exacerbate water supply conditions for California and the western US. Given the very high energy and infrastructure costs associated with conveyance of water across California via the complex aqueduct systems distributing water from Northern California and the Colorado River, increasing attention has been given to water reuse. The State of California recently finalized groundwater recharge regulations for indirect potable reuse using advanced treated wastewater. The State is also required to promulgate regulations for indirect potable reuse through surface water augmentation by the end of 2016, as well as assess the feasibility of direct potable reuse per §13564 of the California Water Code. This presentation discusses the issues, challenges and opportunities for surface water augmentation with advanced treated wastewater for indirect potable reuse in California.
The nitrogen removal characteristics of newly isolated indigenous aerobic denitrifiers from oligotrophic reservoir, Acinetobacter sp. G107 and 81Y

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Nitrogen is considered to be one of the most widely pollutants leading to eutrophication of freshwater environmental ecosystems, especially in the drinking water reservoirs. In the present work, oligotrophic aerobic denitrifiers were obtained which were isolated from the sediments of a reservoir, and nitrogen removal performances were also explored. The results showed that the strains were identified as Acinetobacter sp. G107 and 81Y, based on 16S rRNA gene sequence analysis. Meanwhile, Acinetobacter sp. G107 and 81Y can express periplasmic nitrate reductase gene (napA). And obvious denitrification occurred when cultured in nitrate-medium and nitrite-medium. The denitrification rates were 88.44±0.55%, 85.36±0.07% in nitrate-medium, and 66.78±1.19%, 62.42±2.89% in nitrite-medium, respectively. And Acinetobacter sp. G107 and 81Y were able to occur simultaneously aerobic nitrification-denitrification. The ammonia removal rate reached 34.31±3.51% and 34.87±7.36%, no nitrate and nitrite accumulation, in ammonia-medium. Acinetobacter sp. G107 and 81Y were inoculated into the sterilized reservoir source water and unsterilized reservoir source water with the dissolved oxygen level at 5~9 mg/L, pH 7~9, N/C 1.14:1(TOC = 3.06 ± 0.05 mg/L). The nitrogen removal rates reached 61.45±3.62% and 56.51±3.55% in sterilized reservoir source water; and 45.82±1.02% and 40.06±2.75% in unsterilized reservoir source water, respectively. The cell optical density suggested the strains could survive in the oligotrophic drinking water reservoir water conditions, and performed nitrogen removal ability. The results from this work, therefore, demonstrated that Acinetobacter sp. G107 and 81Y can be used as microbial inoculums for nitrogen removal in micro-polluted reservoir water ecosystem, and a huge potential use for the micro-polluted reservoir water.
Nitrogen removal characteristics of indigenous aerobic denitrifier for micro-polluted source water via in situ enhancement

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Nitrogen pollution has been a serious problem in environmental water, especially in source water ecosystems. In the present work, the indigenous aerobic denitrifiers were enhanced in situ drinking water reservoir and the nitrogen removal characteristics of the indigenous aerobic denitrifiers were explored. The results showed that compared with the blank system, The TN removal rates of water layers (0.5m, 5m, 10m, 13m) in the enhanced system reached 25%, 21.74%, 52.54%, 30.08% and 45.40%, in 30 day’s experiment. The nitrite of the enhanced system reached the highest 0.09mg/L, and then decreased to 0.00 mg/L at the end of the experiment; however, the nitrite of the blank system maintain 0~0.04 mg/L. The TOC of the enhanced system decreased from 4.77 mg/L, 4.73 mg/L, 4.48 mg/L, 4.55 mg/L, and 4.48 mg/L to 2.01 mg/L, 2.20 mg/L, 2.34 mg/L, 2.29 mg/L, and 2.73 mg/L; while that of the blank system from 3.36 mg/L, 3.29 mg/L, 2.52 mg/L, and 3.81mg/L to 6.12mg/L, 6.57mg/L, 6.43mg/L, 6.27mg/L, and 6.54mg/L. CODMn and BOD5 had the same trend with the TOC between enhanced system and blank system. The densities of aerobic denitrification bacteria in the experimental and control systems ranged from 5.5×10^5 to 2.90×10^6 cfu/mL and from 4.92×10^5 to 5.5×10^5 cfu/mL, respectively. It is, therefore, suggested that the enhanced indigenous aerobic denitrifiers were able to achieve effectively nitrogen removal and provided a significant reference to remediate the micro-polluted reservoir water.

Nitrogen Removal Characteristics of Enhanced In Situ Indigenous Aerobic Denitrification bacteria for Micro-Polluted Reservoir Source Water

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Nitrogen pollution has been a serious problem in environmental water, especially in oligotrophic reservoir source water ecosystems. In the present work, the indigenous aerobic denitrification bacteria were enhanced in situ oligotrophic drinking water reservoir and the nitrogen removal characteristics of the enhanced indigenous aerobic denitrifiers were explored. We then conducted a source water remediation experiment, adding the nitrate source as nitrogen source, together in a sample of source water at 4.05~11.89 °C with dissolved oxygen content 3.52~10.84 mg/L for 40 days. The results showed that the nitrate concentrations of water layers (0.5m, 5m, 7.5m, 10m, 13m) in enhanced system decreased from 1.70, 1.71, 1.72, 1.69, and 1.71mg/L to 0.76, 0.79, 0.79, 0.78, and 0.90mg/L; while that in blank system did little to remove the nitrate. No nitrite accumulation. The TN removal rates of the enhanced system reached 39.83%, 39.79%, 36.61%, 37.06% and 38.37%, in 40 day’s experiment. The ammonia concentration maintained 0.3 mg/L. The TOC of the enhanced system decreased from 2.68~3.14 mg/L to 1.90~2.07 mg/L; while that of the blank system remained unchanged. And the BOD5 of enhanced system increased from 2.39~3.02 mg/L to 3.40~4.67 mg/L, while, the BOD5 of the blank did little to change. The densities of aerobic denitrification bacteria in the experimental and control systems ranged from 2.24×10^5 to 8.13×10^7 cfu/mL and from 1.22×10^3 to 8.57×10^5 cfu/mL, respectively. It is, therefore, suggested that the enhanced indigenous aerobic denitrifier was able to achieve effectively nitrogen removal in the micro-polluted reservoir water.
The in situ nitrogen removal characteristics of temperature, water pressure, inoculums to a newly isolated oligotrophic aerobic denitrifier, Zoogloea sp. N299

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Nitrogen pollution has been a serious problem in environmental water, particularly in source water ecosystems. An aerobic denitrifier was isolated from the sediment of oligotrophic reservoir, Zoogloea sp. N299. The nitrogen removal ability of different temperature, water pressure, inoculums conditions were explored through a series of experiment. Based on the temperature distribution of the reservoir, we designed three temperature gradient: 30 ± 2 °C, 18.5 ± 0.5 °C, 11.5 ± 0.5 °C. In the temperature gradient experiment of Hard flask (without water pressure influence) in situ, the nitrate removal rate of the surface flask system reaches 99.21%, the middle flask reaches 61.1%, the bottom reaches 57.66%; the TN removal rate reaches 82.42%, 38.47%, 27.10%, respectively, and no nitrite accumulation in 96h. In the temperature gradient experiment of Soft flask (with water pressure influence) in situ, The TN removal rate of the surface flask reaches 36.40%, the middle reaches 23.74%, the bottom reaches 21.41%. In the different inoculums experiments. The nitrate removal rate of the 1mL/5L system reaches 61.60%, the 2mL/5L reaches 60.02%, the 5mL/5L reaches 61.08%, the 10mL/5L system reaches 60.55% in 96h, in Hard flask; While, in Soft flask, the nitrate removal rate of the 1mL/5L system reaches 55.03%, the 2mL/5L system 49.77%, the 5mL/5L system 53.45%, the 10mL/5L 51.35%; no nitrite accumulation. From all the results, the pressure of the water has a disadvantage to the nitrogen removal and the higher temperature, the better performance of denitrification, and there is no difference in the different inoculums experiment. It has been found that the Zoogloea sp. N299 is able to achieve effectively denitrification and provided a significant reference to remEDIATE the micro-polluted reservoir water.
The Functional Diversity of Carbon Source in Microflora of oligotrophic reservoir with in situ enhanced indigenous aerobic denitrifier system

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With Biolog Eco microplate, metabolic characteristics and functional diversity of carbon in microflora of oligotrophic reservoir with based on in situ enhanced indigenous aerobic denitrifier system and control system in order to explore effects of enhanced-adjustments on microflora in oligotrophic reservoir. The results indicated that total number of bacteria, microbial metabolism activity (AWCD), and diversity index in enhanced indigenous aerobic denitrifiers system were higher than those of the control system. The utilization rates of microbes on sugars achieved from 18.06±2.57% to 16.54±0.96%, amino acid from 9.97±1.88% to 17.49±3.32%, ester from 28.20±2.32% to 22.73±4.66%, alcohol from 11.20±3.04% to 11.35±1.58%, biopolymer from 19.07±1.92% to 17.08±1.42%, carboxylic acid from 13.50±1.95% to 14.81±0.70%, in the enhanced system; While those of microbes were from 9.17±1.74% to 14.10±5.03%, from 8.86±2.69% to 13.99±1.53%, from 33.01±6.18% to 38.54±10.63%, from 15.91±7.38% to 9.73±5.37%, from 15.40±1.56% to 14.53±0.34%, in the control system. Principal component analysis divided microflora in enhanced system and control system, suggesting that microbial community has varied carbon source characteristics. It is, therefore, suggested that the technology of the Biolog Eco microplate is one of the effective approaches to study the diversity of water microbes as it can show the characteristics of the carbon catabolic diversity of water microbes objectively and accurately.

Effects of rainfall patterns on water quality in a stratified reservoir subject to eutrophication: implications for management

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The seasonal variation of hydrological conditions caused by shifting rainfall patterns observed in recent years, has significant effects on the water quality. High-volume inflows following heavy rainfall events that significantly disturb stratification, lead to increased dissolved oxygen (DO) at the bottom, inhibit the release of nutrients from sediments and cause a rapid reduction of algal biomass in the reservoir. Nevertheless, the duration and extent of these effects depends not only on the frequency and intensity of heavy rainfall events, but also on the period of thermal stratification in the reservoir. The effects of heavy rainfall events on water quality in three typical stratification periods of the reservoir were systematically investigated using extensive field data. Continued heavy rainfall that occurred in September 2011(stratification began to diminish), completely mixed the reservoir, and produced a high concentration of DO and a low phytoplankton concentration throughout the reservoir, until stratification occurred the following year. Conversely, several days were required for anoxic conditions (in the hypolimnion) and cyanobacterial blooms to reappear after the storm runoff that occurred during the stable period of stratification (August 2012). In addition, heavy rainfall that occurred in May 2013 accelerated the formation of an anoxic zone at the bottom, and promoted cyanobacterial blooms due to the high nutrient input and the increased water temperature after the storm runoff stopped. Water-lifting aerators (WLAs) were employed in the Shibanyu Reservoir to inhibit algal growth and control the release of nutrients. Based on our field observations and theoretical analysis, optimized management strategies are recommended to improve water quality in the reservoir with lower cost under different rainfall patterns.
Study of the application of a water-lifting aerator to improve the water quality of a stratified, eutrophication reservoir

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Cyanobacterial blooms accompanied by a release of nutrients from the bottom sediments in the stratified summer period continue to be a serious nuisance to water quality managers. Water-lifting and aeration technology can be used to inhibit algal growth while controlling endogenous pollutants. In this study, two water-lifting aerators (WLAs) were installed in a stratified, eutrophication reservoir to investigate its ability to improve the water quality. The results showed that the lower water layer was oxygenated by the circulation flow and directly oxygenated by WLAs. After the WLAs operated for a month, the concentration of dissolved oxygen at the bottom increased from 0 mg/L to 5 mg/L; the release of endogenous pollutants had effectively been suppressed. The advection generated by the circulated flow from WLAs can transport algae from the surface layer to the bottom layer. The mixing function of WLAs can control algal growth, and its mixed conduction speed gradient can effectively resist cyanobacteria floatation and reduce the competitive advantage of harmful algae, which changes the quantity and structure of the phytoplankton community. The algal cell density decreased to less than 10 million/L, with cyanobacteria accounting for only 16% of the population 10 meters away from the WLA. The quantity of algae reached to 100 million/L and included Microcystis, which accounted for 91% of the population 100 meters away from the WLA after three weeks of operation. The results can provide direct technical support for reservoir restoration.

Shifts in Bacterial and Fungal Communities during the Decline of Phytoplankton Blooms in the Drinking Water Reservoir

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Drinking water reservoir harbored several microbial species; including bacteria, fungi, and alga, however, the changes of microbial communities during the decline of phytoplankton blooms in the drinking water reservoir were not well understood. In the present work, carbon utilization profile, quantitative PCR and high-throughput sequencing Miseq techniques were combined to decrypt the dynamics of bacterial and fungal metabolic, abundance and genetic fingerprints during the decline of algal blooms in Zhoucun drink water reservoir, eastern China. The sampling processes were carried out from July to September 2012. The results showed that Aphanizomenon sp. (relative abundance 1.70%), Microcystis sp. (8.19%), Synechococcus sp. (62.71%) Limnothrix sp. (5.53%), Planktothrix sp. (6.26%), and Prochlorothrix sp. (15.60%) were the dominated Cyanobacteria. The bacterial and fungal communities metabolic activities were increased significantly during the decline (P<0.01). Batrachochytrium sp. and Occultifur sp. were the dominated fungal species during the beginning of the bloom, Catenaria sp. Pseudogymnoascus sp. Fusarium sp. Meanwhile, Tomentella sp. was only observed in the end of the bloom. Principle component analyses (PCA) suggested that there is a significant shift of bacterial and fungal communities from the beginning to the decline of algal blooms. The results from present work revealed that the decline of phytoplankton blooms had significantly influenced the changes of the bacterial and fungal community compositions in Zhoucun reservoir. It is therefore that release of extracellular exudates by phytoplankton and uptake by algal associated bacteria and fungi should be well documented the algal–bacterial and fungal interaction in this freshwater ecosystems.
Integrated Water Quality Management and Indirect Potable Use

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As a small nation of about 700 square kilometres in area, Singapore has limited land catchment and storage of rain water. As water remains a scarce resource in Singapore, there is a need to ensure its long-term sustainability through effective and efficient management of diversified water sources including water reuse. The PUB is the national water agency that takes charge of all aspects of water management in Singapore; viz. to collect and manage raw water inclusive of reclaimed water that is used to augment the supply (indirect potable use), to produce and supply potable water, and to treat and recycle used water to produce NEWater. To ensure water safety, it is essential to have an effective water quality management system for the entire water loop which includes water catchments, waterways and reservoirs; waterworks and potable water distribution systems. PUB has put in place a comprehensive Integrated Water Quality Management to safeguard water quality which includes indirect potable use, for water safety. This presentation is a case study based on Singapore’s experience on comprehensive water quality monitoring to manage and safeguard water quality from source to taps. The presentation will also cover Singapore’s efforts in research and development to enhance the efficiency of water quality monitoring to facilitate prompt assessment and response to any water quality incidents.

Understanding reservoir contaminant impacts through proactive modeling efforts

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This study presents a framework for using hydrodynamic and water quality models to understand the fate and transport of potential contaminants in a reservoir and to develop appropriate emergency response and remedial actions. In the event of an emergency situation, prior detailed modeling efforts and scenario evaluations allow for an understanding of contaminant plume behavior that may influence treatment process decisions, including maximum concentrations that could occur at the drinking water intake and contaminant travel time to the intake. A case study assessment of the Wachusett Reservoir, a major drinking water supply for metropolitan Boston, MA USA, provides an example of an application of the framework and how hydrodynamic and water quality models can be used to quantitatively and scientifically guide management in response to a variety of contaminant scenarios. In this example, the model CE-QUAL-W2 was developed and calibrated based on data from the calendar years 2003 through 2012 and verified by temperature and specific conductivity profiles. The model was used to investigate the water quality impacts of several hypothetical contaminant scenarios, including fecal coliform input from a sewage overflow as well as accidental road and railway spills of ammonium nitrate and fuel oil. Scenarios investigated the impacts of decay rates, season, and inter-reservoir transfers on contaminant arrival times and concentrations at the drinking water intake. The modeling study highlights the importance of a rapid operational response by managers to contain a contaminant spill in order to minimize the mass of contaminant that enters the water column, based on modeled reservoir hydrodynamics. The development and use of hydrodynamic and water quality models for surface drinking water sources subject to the potential for contaminant entry can provide valuable guidance for making decisions about emergency response and remediation actions.
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Application of the technology of lifting water and aeration for improving water quality in a plain reservoir

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The technology of lifting water and aeration was novel for its improvement of water quality mixing of water, controlling algae growth, increasing dissolved oxygen in water, and constraining the release of pollutant in sediment. This technology was applied in some Gorge reservoir in north of China before and excellent results have been achieved. When it was applied in a plain reservoir, some different shown up. Therefore, we optimized its construction and operation mode, expect to obtain a optimal treatment effects. In this paper, we analyses the differences of thermal stability between the two different types of reservoirs use the Schmidt’s stability index (SSI), based on the water temperature monitoring results for many years. And a Computational Fluid Dynamics Simulation software was used to explain the difference between the two different types of reservoirs when the technology of lifting water and aeration was applied. The most critical influences was that (1) There was a higher thermodynamic stability in Plain reservoir than Gorge reservoir (2) The wide free water surface of Plain reservoir adverse to form a circulation in the water body. And on this basis we designed a more effective air release device in the device for lifting water and aeration and readjusted the starting up season. When the new device for lifting water and aeration applied in a plain reservoir of North China Plain, it effective control the eutrophication phenomenon and reduce Chlorophyll—a over 25%.

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Effects of thermal stratification on water quality of reservoir—a case study of Zhoucun reservoir, China

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In this study, thermal stratification and vertical variability of water quality in Zhoucun reservoir were explored in to figure out the dynamic of water quality in Zhoucun reservoir and clarify the crucial parameters which influence its ecological and chemical status. Water/sediment samples were collected in 2012 and 2013. pH, temperature, dissolved oxygen, electrical conductivity, total phosphorus, total nitrogen, ammonium, nitrate, nitrite, chemical oxygen demand, sulfide, total Fe and Mn were determined. The results has shown that a thermal stratification was observed in the reservoir from April to November. The stabilized condition of temperature gradient has efficiently limited the mass transfer of dissolved oxygen between the vertical layers of water, thus resulted in the transition of bottom water into anaerobic condition and the average concentration of dissolved oxygen in monimolimnion decrease in linear attenuation with the pass of time. In regard to the sediment, respiration rate is 7.51-11.08 mg/(m³•h). In anoxic/anaerobic condition, large amount of chemical elements such as N/P/Fe/Mn/S are released from the sediment and has diffused into the overlying water layer, contaminating the quality of bottom water layer. During the mixed water period (from November to the next March), the thermal stratification disappered and the reservoir was then in an aerobic condition (DO>8mg/L), with its vertical layer becoming homogeneous. The stabalized condition of thermal stratification is an important factor in the eutrophication of the water in Zhoucun reservoir, which poses a serious problem to the water supply plant.
Using Aquatic Ecosystem Models to support lake and reservoir management

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Reservoirs are heavily used and managed water bodies. Different interests on water usage easily come into conflict with each other. The depth and amount of water withdrawal is a management tool that strongly affects ecosystem dynamics within reservoirs. In this study, two examples of withdrawal management were investigated. The first reservoir ("Bautzen reservoir") is a large and shallow reservoir in Eastern Germany, which is mainly used for the supply of cooling water. In the past, the reservoir suffered from massive cyanobacterial blooms. However, during recent years the water level could be kept at a constant high level, resulting in a more stable stratification during summer. Thereby, nutrients dissolved in the hypolimnion were locked away from the productive zone and no cyanobacterial blooms could develop. Through a modelling study, the question was addressed if a changed withdrawal regime could intensify the thermal stratification in the water column in order to avoid nutrient upwelling into the epilimnion. A switch from hypolimnetic to epilimnetic withdrawal resulted into a more stable stratification within the reservoir. Simulations where used to define a minimal water level above which mixing events remain low.

The second reservoir ("Grosse Dhuenn Reservoir") is a deep reservoir in Western Germany, used for drinking water supply. In the past, water was withdrawn from the hypolimnion, leading to relatively low water temperatures in the downstream river and causing a shift in the fish population towards cold adapted species. A change in withdrawal depth shall reverse this shift. The effects of epilimnetic withdrawal on stratification structure and hypolimnetic oxygen concentrations within the reservoir are analysed with a complex aquatic ecosystem model. Additionally, a tool will be developed to support decision making on optimal withdrawal depth.
Oxygenation stimulates hypolimnetic phytoplankton in a drinking water reservoir

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Hypolimnetic oxygenation is increasingly used to improve water quality and suppress phytoplankton growth in freshwater lakes and reservoirs. However, all studies to date examining the efficacy of oxygenation have focused on the effects of altered redox conditions on internal nutrient or metal loads, and not biological response variables. Here, we examined the effects of oxygenation on the phytoplankton community in Falling Creek Reservoir, a drinking water source and GLEON site located in Vinton, Virginia, USA. This reservoir has a hypolimnetic oxygenation system that was turned sequentially on and off for ~4 week periods during the summer of 2014. We used a Fluoroprobe® fluorometer to quantify the abundances of four different phytoplankton groups: cryptophytes, cyanobacteria, diatoms, and green algae, on ~10 cm interval depth profiles throughout the water column weekly throughout summer 2014; we will sample semiweekly in summer 2015 to continue monitoring the effects of oxygenation on phytoplankton. Surprisingly, hypolimnetic abundances of all four phytoplankton groups increased when the oxygen system was activated. The Fluoroprobe data provide insight into the effects of dissolved oxygen on phytoplankton community composition and succession, and indicate that hypolimnetic oxygenation may actually stimulate, not decrease, phytoplankton abundance.

A field scale Living-Filter and mesocosms experiment to identify physico-chemical and biological mechanisms for phytoplankton biomass reduction

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A hydroponic bed of floating-reeds, the Living-Filter (L-F), was designed and installed by Thames Water and AquaticEngineering in Farmoor reservoir, Oxfordshire (July 2012). The structure (1 m H x 21 m W x 10 m L) supports plants of Phragmites australis, Phalaris arundinacea and Carex acutiformis, with a combined system of curtains and baffles that aid the water to flow through the L-F. All abstracted water at the tower inlet has passed through the L-F. The aim is to reduce the phytoplankton biomass onto the water treatment works at the abstraction point. Physicochemical and biological variables were measured at 16 sampling sites. Results show soluble manganese (sMn) levels were higher at the sites outside the boundaries of the L-F. Differences in levels between sites in the Living-Filter platform were found for iron, manganese and sMn. Also a significant accumulation of chlorophyll a (Chla) and total phosphorus. Differences in particle organic carbon and total suspended solids levels seem to be related to the on-site reeds. Significant Chla reduction has yet to be seen at the abstraction point. This might be explained by: a high flow rate through the L-F (9.5–15.9 m h-1) for effective grazing/trapping by the zooplankton/biofilm compared to that of slow sand (0.2 – 0.6 m h-1); the role of increased fry fish numbers within the L-F boundaries; the dimensions of the L-F to the reservoir. Based on root development future designs will only be carried out with Phalaris and Carex. The complexity of the L-F field scale hampers the identification of the relevant mechanisms. A continuous flow mesocosms experiment with Phalaris and Microcystis is being carried out; preliminary results show the relevance of chemical mechanisms in the process.
Effect of rainstorm flow undercurrent on water quality and the selective water withdraw scheme in the flooding season of a deep canyon-shaped reservoir

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Rainstorm and continual runoff events in the flooding season affect water quality of reservoir and increase risks for water supply. The phenomenon of turbid current intrusion resulting in water turbidity and increasing difficulty for water plant treatment was observed in the flooding season in Heihe reservoir, Xian, north China. Heihe watershed has a semi-moist monsoon climate and the annual average rainfall is above 900 mm in the mountainous area. The flooding season lasts from July to September and over 60% of the annual precipitation centralized in the flooding season. In recent years, extreme rainfall events occurred more frequently and strongly affected the water quality of Heihe reservoir. In this study, the effect of rainstorms on water quality was investigated by field observations through 10 representative sections from the inflow area to the dam during the flooding season. Temperature, turbidity, depth, ORP, electric conductivity and dissolved oxygen were monitored by Hydro-lab DS5 device and water velocity was monitored by ADCP. According to twice-monthly measurements and more frequent measurements during the flooding season, the intrusion depth, intrusion thickness and existing time of high turbidity water in Heihe reservoir were clarified. The results showed more flexible water withdraw scheme should be adopted under different raining conditions and more attention should be paid to the inflow volume in flooding seasons. Based on the characteristics and impact of turbidity current on water quality, a selective choice of water intake may provide an efficient means to reduce risks for the urban water supply. The results can provide direct technical support for reservoir operation and safe water intake for Heihe reservoir.

Oxygen consumption and nitrogen cycle in the hypolimnion of a source water reservoir in North China

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Zhoucun reservoir is a medium-scale reservoir in Shandong Province, North China. The hypolimnion of the reservoir rapidly goes anoxic after thermal stratification in every April. Field and laboratory studies were conducted to examine the feasibility of using oxygenation to avoid hypolimnetic anoxia and subsequent accumulation of ammonia in the hypolimnion, and to estimate the required DO capacity of an oxygenation system for the reservoir. To do this, we designed a series of experimental chambers, which could monitoring the change of water quality indicators in the hypolimnion. The experimental chambers have installed in the bottom each season for forty days. Sediment oxygen demand (SOD) determined in experimental chambers averaged approximately 0.178 g O2 m−2 d−1. The accumulation of inorganic nitrogen in water overlaying sediment was measured in the chambers else. Rates of ammonia accumulation ranged from 10.3 to 25.0 mg-N m−2 d−1 in chambers with different dissolved oxygen concentration, and it has a maximum accumulation rate in the autumn. Nitrate Nitrogen concentration decreased in anaerobic and aerobic state both, which is a proof of aerobic denitrification process. In the in situ experimental chambers, the aerobic denitrification process was observed when the DO concentration limit up to 4 mg/L. In the further research, a laboratory studies was taken, which determined the most suitable DO range between 2.0–4.0 mg/L and isolated some oligotrophic aerobic denitrifier, such as Zoogloea sp. N299.
Impact of inflowing water temperature on the algal concentration in a stratified subtropical reservoir

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Algal blooms occur frequently in Shin-Shan Reservoir, an off-channel subtropical reservoir in Taiwan, from April to October every year. However, the concentration of phytoplankton cells varies. Sometimes the algal bloom disappears even in the mid-summer for a period of time and appears again. Investigation of the water quality and the temperature profile had been conducted monthly from 2009 to 2010 as well as those of the Keelung River, where the water is drawn and pumped to the reservoir. It was found that the algae bloomed seriously after a period of time when the water temperature of Keelung River was higher than the temperature in the surface water layer in the reservoir. Contrastingly, the bloom disappeared suddenly few days after the river temperature dropped below the surface temperature of the reservoir. The density/temperature of the inflowing water relative to the density/temperature of the stratified reservoir water column is suggested to be the regulating factor for supplying nutrients to the euphotic zone for the growth of algae, or carrying nutrients to the deep water layer and making them unavailable to algae.

CE-QUAL-W2 water quality model was used to simulate the effects of inflowing water temperature to the algal concentration in Shin-Shan reservoir. The model is able to assign the inflowing depth in the stratified water column according to the inflow temperature and the vertical temperature profile in the reservoir. Simulations of water quality parameters, including the concentration of chlorophyll a, by using verified model matche the field data will. The impact of a period of warm weather on the algal density in a subtropical stratified reservoir is obvious.
Effects of reservoir hypoxia on zooplankton community composition and vertical distribution

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As a result of global change, hypolimnetic hypoxia has increased in lakes and reservoirs. Hypoxia can have many detrimental effects on freshwater ecosystem functioning, such as increased internal nutrient and metal loads from the sediments. Although the effects of hypoxia on nutrient release has been well studied, less is known about how hypoxia impacts plankton communities in the water column, especially zooplankton. Typically, zooplankton exhibit diel vertical migration, in which they migrate to the dark hypolimnion during the day to escape visual fish predation in the epilimnion. However, in the physiologically-stressful conditions of hypoxic hypolimnias, it may be possible that zooplankton no longer migrate: i.e., they are faced with a trade-off of the stress from hypoxia vs. predation. We sampled six reservoirs weekly to bi-weekly in southwestern Virginia from May–September 2014 to examine how hypolimnetic oxygen concentrations impact the spatial distribution, abundance, biomass, and community composition of zooplankton. These reservoirs varied on a gradient of hypolimnetic oxygen concentrations, from anoxic to oxic at the sediment-water interface during most of the thermally-stratified period. We collected full water column and epilimnetic zooplankton tows to quantify the relative abundance and biomass of different zooplankton genera in the epilimnion and the hypolimnion across these reservoirs. We hypothesize that in hypoxic conditions, zooplankton will be predominately found in the epilimnion, especially larger organisms that require more oxygen. Because of the critical role zooplankton play in lakes and reservoirs as the dominant grazers of phytoplankton, it is vitally important to better understand how they may respond to hypoxia and anoxia, especially as these conditions increase in the future.
Effects of Lake Oxygenation operations on the sediment oxygen demand

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As a solution to the growing problem of oxygen depletion in reservoirs, hypolimnetic oxygenation is increasingly utilized to replenish DO while preserving the ecosystem (i.e. thermal stratification). Even so, the mixing that results from HOx operations, induces the increased sediment oxygen demand (SOD). In their studies, Bryant et al (2011), observed SOD was correlated with the HOx gas flow rates during HOx operation. In order to predict the changes in SOD as a result of HOx operation, there is a need for a better understanding of how increasing the bubble flow rate would result in the increase in SOD. The effect of bubble plume operation on SOD was studied through in situ measurements of temperature, DO profiles, current velocities and wind data in Carvin’s Cove Reservoir (CCR), a eutropic and relatively shallow lake in Virginia. The oxygenation diffuser in CCR is a line source located along the edge of the deepest region of the hypolimnion. During a multi-day campaign, we manually changed the gas flow rates of the diffuser daily to observe the resulting physical processes. Thermistor data, wind data, turbulence and the vertical distribution of dissolved oxygen above and within the sediment were analyzed. Analysis of the data showed that the bubble plume function influences the SOD through two dominant processes. The change in the bubble flow rate excites the internal waves which generate unsteady currents. Also, bubble plumes create recirculation and induce mixing. Observations showed the importance of accurately incorporating the internal motions in the numerical models.

Humans are Excellent at Detecting Changes in Aesthetic Water Quality, but can They Describe the Differences?

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A strategy for water quality experts and drinking water providers to resolve aesthetic issues in source and treated water is applying: 1) sensory analysis to describe taste, odor, or color; 2) chemical analysis to confirm and measure the causing compounds; 3) treatment to remove the causes. Globally, consumers are experts at detecting differences and are often first responders to changes in aesthetic water quality through their complaints/feedback. Consumer feedback should therefore be immediately documented, tracked, and analyzed. Professionals who process communications from consumers should do this within the context of variability in human senses. While visual assessment can readily and accurately describe colors, over a trillion olfactory stimuli exist. Consumers are thus challenged to describe odors when they have neither the lexicon nor the expectation of odors in their drinking water. We demonstrate that data visualization techniques of spider (or radar) and run-time plots can determine patterns and help identify the aesthetic issue. For example, worldwide, the aqueous odor threshold concentrations (OTC) of algal metabolites geosmin (earthy) and 2-MIB (musty) range from 1-10 ng/L, although anosmia is not uncommon. Consumer descriptors for geosmin and 2-MIB can vary from the “official” earthy/musty to medicinal, camphor, chlorine, or just not good, often with apparent cultural variations. Likewise, the sulfurous microbial degradation product dimethyltrisulfide has an aqueous OTC of 1.7 ng/L with official garlic, onion descriptors. Consumers described dimethyltrisulfide by widely varying terms, from wet to drainage and fecal. Thus, when odorous compounds are present, consumer feedback may need to be probed to interpret the underlying aesthetic issue. These examples show that through sensory and chemical analysis, water utilities can improve consumer confidence in their drinking water.
The effects of oxygenation on metal concentrations in a small, eutrophic drinking water reservoir

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Reducing conditions at the sediment-water interface (SWI) are favorable for the release of manganese (Mn) and iron (Fe) from the sediments into the reservoir water column. Hypolimnetic oxygenation has been used to inhibit the release of Mn and Fe that occurs under low oxygen conditions in stratified reservoirs. This study investigates whether hypolimnetic oxygenation in a shallow, eutrophic drinking water reservoir can effectively suppress the release of Mn and Fe from sediments into the water column and how rapidly Mn and Fe is removed from an oxic water column.

This study was conducted at Falling Creek Reservoir in Vinton, VA which has a maximum depth of ~9.3 m and experiences thermal stratification from late April through October. Nutrient and metal (raw and filtered) samples were collected weekly from 9 depths in the reservoir and in the surface water inflow during the stratified period. Dissolved oxygen (DO) profiles in the water column were collected weekly. The oxygenation system was manipulated to develop hypoxic conditions (<2 mg/L DO) for up to 4 weeks at a time. Following hypoxic intervals, the system was turned on to restore well oxygenated conditions (>8 mg/L DO) in the hypolimnion.

Our results show that Mn and Fe concentrations are highest near the SWI throughout the stratified period, suggesting that oxygenation does not prevent the release of metals from the sediment. However, during oxic conditions the particulate fraction for both Mn and Fe increases when DO in the hypolimnion is greater than ~6 mg/L, suggesting that soluble Mn and Fe are oxidized to insoluble oxide/hydroxides under these conditions. Overall, our results suggest that an oxic water column may not prevent the release of soluble metals but it will cause the oxidation to insoluble forms that are more easily removed during treatment.
Elimination of Phosphorus Loads by the Advanced Bioretention System

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Excess phosphorus (P) significantly impairs lentic ecosystems by stimulating algal growth. Neither floating nor emergent wetlands provide the P removal needed to restore mesotrophic status. Effective removal of excess P within the water body is only possible by alum addition, which is expensive and potentially toxic. Therefore, inflowing runoff must be treated before entering the reservoir.

Bioretention systems are classified as intermittently saturated vertical flow constructed wetlands (VFCWs). Hydraulic loading rates are an order of magnitude greater than conventional horizontal flow CWs (HFCWs). The advanced bioretention system (ABS) is a VFCW that substantially improves removal of nitrogen (N) and P from runoff.

After four years of mesocosm studies accumulating 220 gP/m², the ABS retained 79% dissolved P (DP) and 94% ortho-phosphate (PO₄). A full scale ABS in the US confirms these findings over the last two years, retaining over 90% DP and over 95% PO₄. In column studies in Singapore, equilibrium DP concentrations were 0.016 mg/L after accumulating over 500 gP/m².

The ABS system is also quite effective for nitrogen (N) retention, with TN reductions as high as 75%. These findings are being confirmed in a full scale installation adjacent to the Kranji Reservoir in Singapore. This will include 10 different plant taxa ranging from grasses, landscaping perennials and woody shrubs, to biomass species. Each treatment will be individually monitored.

The ABS comprises a 340 m² facility treating 3.8 ha of highly enriched runoff (base flow DP 6 mg/L) at very high rainfall depths (>3m per year). It is about to go out for construction tender, to be completed this fall. This presentation will summarize the original research and US studies, and present the ABS design. Applied watershed-wide, the ABS technology could eliminate the nutrient loads responsible for eutrophication of Kranji Reservoir.
The Human Monitoring Element: Is Current Aesthetic Guidance for Iron and Manganese Adequate for Consumer Acceptance?

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Principle reasons for controlling iron and manganese in lakes, reservoirs, and tap water are the aesthetic effects of taste, odor, and color that cause problems for consumers, industries, and water utilities. Worldwide, regulatory guidance targets concentrations of 200-300ppb Fe and 50-100ppb Mn to avoid aesthetic issues. These values have existed for over 50 years; recent sensory and water quality data indicate consumers are able to monitor and detect much lower concentrations, depending on the metal’s oxidation state. Consumer testing demonstrates that the population flavor threshold for iron ranges from 30-170ppb Fe(II), and is influenced by age. The population taste threshold for manganese is considerably higher at 75-100ppm Mn(II), and is not influenced by age. The difference in flavors of iron and manganese is related to retronasal metallic odors produced by salivary lipid oxidation within the oral cavity. Iron(II) oxidizes lipids and saliva to produce flavor compounds, while Mn(II) does not. Neither Fe(III) nor Mn(IV) cause salivary lipid oxidation and consumers do not detect a flavor. Consumer testing revealed that Mn(IV) was readily detected at concentrations of 5ppb Mn(IV) when compared to deionized water. Fe(III) was also visible with individuals detecting off color at 60ppb Fe(II). The reduced forms of manganese and iron are colorless at concentrations much greater than regulatory values. Human ability to detect off flavors and colors is variable, therefore there are individuals who are more or less sensitive than reported concentrations. It is clear consumers can monitor water quality and current regulatory guidance is insufficient to protect against off-colors of Mn(IV) and Fe(III) or off-flavors of Fe(II). To maintain consumer and industry confidence, both iron and manganese should be removed to below sensory thresholds in drinking waters.
Causes and Implications of Increased Salinity of Freshwater Lakes, Reservoirs, and the Rivers that Supply Them

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The combination of natural causes and direct anthropogenic activities are the source of a worldwide trend in increased salinity for freshwater lakes, reservoirs, and rivers. Many of the drivers of increased salinity are directly or indirectly linked to climate change. This presentation will explore known causes, effects, and severity of salinization. A specific focus will be to address anthropogenic salinization as spatial and temporal changes for both overall total dissolved solids (TDS) as well as individual anions and cations. As an example, currently in the USA, 12.6% of surface waters exceed 500 mg/L TDS, an upper value desirable internationally for healthy fish and appropriate drinking water quality. Too many USA waters are in the 1000-5000 mg/L TDS range, which is borderline unsuitable for drinking, irrigation, and livestock. About two-thirds of salinity is attributable to natural causes, including drought, while one-third is directly anthropogenic causes primarily from deicing agents and wastewater/reuse water influenced by industry, agriculture, and consumer products that primarily add sodium, sulfate, chloride and magnesium. Many municipal wastewaters are acknowledged to contribute increased TDS to receiving waters; this TDS may impact a wastewater’s applicability for reuse. Similar situations are being observed across the globe due to increased population, agriculture, industry, and mining. The consequences of too much salt include ecosystem damage, loss of biodiversity, unhealthy fish populations, unhealthy livestock, crop damage, poor tasting water, adverse human health effects, and lower quality food and beverage products. Collectively, increased salinization is costly and a challenge to treat because soluble ions are difficult and costly to remove and primarily require membrane processes. Mitigation strategies for controlling salinization are complex and involve changes in water use, hydrology, and treatment.
A Mobile Platform to Quantify Toxin and T Compound Producing Cyanobacteria in Drinking Water Reservoirs

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Cyanobacteria, an important group of microorganisms present in many drinking water reservoirs, may produce cyanotoxins and taste and odor (T) compounds, posing health-risk and aesthetic issues to consumers. Quantification of cyanotoxins, T compounds and their producing cyanobacteria in drinking water reservoirs are therefore needed for proper management of water supplies. Microscopy, gas chromatograph, and liquid chromatograph are currently used as standard practices to quantify the producing cyanobacteria, T compounds, and cyanotoxins, respectively. However, these established methods require experienced biologists, sophisticated instrumentation, and/or long turn-around time. Bio-molecular methods, such as quantitative polymerase chain reaction (qPCR), offer the capability of quantifying functional gene concentrations of targeted cyanobacterial metabolites in short time, which may provide additional information and time for the management of water supplies.

The aim of this study is to develop and apply an on-site mobile monitoring system to quantify the concentrations of functional genes responsible for the production of five commonly observed toxins and T compounds produced by cyanobacteria, including microcystin, cylindrospermopsin, saxitoxin, 2-MIB and geosmin, in Taiwan’s reservoirs. Primer and probe sets were first designed and tested with pure cyanobacteria strains, including producers and non-producers of the targeted metabolites. Then, the method was integrated with a mobile laboratory and applied in quantifying the toxin- and odorant-producing species in 38 drinking water reservoirs in Taiwan. The qPCR results obtained in the reservoir samples well correlated with the cyanotoxin and T compound concentrations measured for the corresponding samples. The results suggest that the qPCR based approach may offer a quick and specific detection method for the monitoring of cyanotoxin and T compound producing cyanobacteria in water sources, allowing more time for reservoir and water utility managers to action when faced with cyanobacteria associated episodes.
Seasonal variation of Trihalomethanes precursors in a naturally eutrophic coastal lake in South Brazil. Bank filtration as water treatment option.

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The presence of phytoplankton (10^-5-10^-6 cells/mL), including cyanobacteria cells, compromises the use of Lagoa do Peri lake as water source. The cells cause the formation of trihalomethanes (THMs) after chlorination. The aim of this study was to characterize the seasonal variations of THMs precursors and lake bank filtration (BF) for water treatment. Lake and 12m depth well water were monitored during one year. Lake water temperature ranged from 15 to 20 °C from June to October and 20 to 28 °C from October to May. Total, particulate and dissolved organic carbon (TOC, POC and DOC) changed from 5.9±1.1 to 9.1±1.3 mgC/L, 4.0±1.3 to 6.0±0.9 mgC/L and 2.0±0,7 to 3.0±1,0 mgC/L respectively. The THMs precursors, measured in terms of total trihalomethanes formation potential (THMFP), presented a similar pattern 434±92 to 533±100 μgCHCl3/L. Low correlations between THMFP and TOC (r=0,496) and THMFP and DOC (r=0,428) were found. However, the THMFP measure in filtered samples ranged from 286±50 to 280±59 μgCHCl3/L and, THMFP related to particulate matter changed from 185±41 to 247±82μgCHCl3/L. That, together with higher values of the chlorophyll-a (20±9 µg/L) during the warmer months shows the contribution of phytoplankton in the formation of THM precursors. The well water showed no phytoplankton, 3.6±1.6 mgC/L (14% removal), 4.3±1.7 mgC/L (28% removal) and 195±42 μgCHCl3/L (52% removal) of DOC, TOC and THMFP respectively. The percentage removal of THMFP indicates a preference for precursors reduction during BF. However, the principal drawback of BF is a change to anoxic conditions in well water.

Cyanobacteria as drivers of lake nitrogen and phosphorus cycling

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Cyanobacterial blooms pose a major threat to lake and reservoir ecosystem services worldwide. Conventional wisdom holds that freshwater cyanobacterial blooms are a consequence of human activities in watersheds. However, this view overlooks interesting aspects of cyanobacterial biology that can profoundly affect lake ecosystem function: many cyanobacteria fix nitrogen (N) and some access phosphorus (P) from the sediments and hypolimnion. Because these activities tap into pools of N and P that are not usually accessible in the epilimnion, cyanobacteria may have the potential to drive a regime shift from a low-nutrient (oligotrophic) state to a high-nutrient (eutrophic state) and to maintain the resilience of eutrophic systems to restoration. A simple model of coupled N and P cycles generally supports this hypothesis: parameters reflecting cyanobacterial modification of N and P cycling consistent with cyanobacterial activities have the potential to alter the number, location, and/or stability of model equilibria. Moreover, emerging empirical evidence from low-nutrient lakes suggests that some cyanobacterial taxa may help facilitate eutrophication. As such, cyanobacterial blooms may warrant attention as potential drivers of regime shifts in lakes and reservoirs.
Variable Sediment Oxygen Flux in Oxygenated Lakes: From Field Observations Toward a Comprehensive model

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Hypolimnetic oxygenation systems (HOx) are commonly used to mitigate hypoxia/anoxia in stratified lakes and reservoirs. Following HOx installation, increases in sediment oxygen flux (JO2) are often observed, and are positively correlated with HOx gas flow rate. Studies show that JO2 is controlled by the thickness of the diffusive boundary layer (DBL) at the sediment-water interface (SWI), which is in turn controlled by near-sediment turbulence. Therefore, JO2 is potentially quite variable, both spatially and temporally.

Near-sediment velocity measurements and oxygen microprofiles across the SWI were collected during three field campaigns on two oxygenated lakes. These data were used to estimate turbulence and JO2. Field observations show that HOx operation can increase JO2 by enhancing turbulence, which decreases DBL, and by increasing bulk hypolimnetic oxygen concentrations, which increases the concentration gradient across the SWI. Existing models of interfacial flux were then compared to the field measurements to determine which model best predicted the observed JO2. Models based on the integral scale, Batchelor scale, and friction velocity all agree reasonably well with field observations in both lakes studied.

These interfacial flux models have been incorporated into a coupled 3-D hydrodynamic reservoir and bubble plume model for Carvins Cove Reservoir, allowing for spatial and temporal variation in simulated JO2. This comprehensive model was calibrated to 2011 field data and validated to 2013 field data. This model can then be used to further understand the impact of HOx operation on JO2, as well as the spatial and temporal variation in JO2.
Streamflow dynamics associated with climate changes and anthropogenic disturbances in a subtropical coastal watershed of China

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It is essential to understand the dynamics of streamflow across different physiographic regions so as to formulate sound strategies for water resource management. The reality is that the coupled impact of climate changes and anthropogenic disturbances on streamflow regime is less well known in coastal watersheds with intensive human activities and subsequent water resource crisis. The eco-hydrological approach was modified and then applied in this study to identify the relative impact of climate changes and anthropogenic disturbances on the dynamic runoff changes using the fifty-year hydro-climatic data of Jiulong River Watershed, a typical medium-sized subtropical coastal watershed in China by analyzing the trend of excess water (Wex) and excess energy (Eex). Our study showed that runoff regime response to climate variability was obviously controlled by anthropogenic disturbances in JRW over the past five decades. Increasing trend of Wex and Eex during 1960s, 1980s and 1990s indicated the amplified runoff due to land changes. Dramatic deforestation occurred during these periods associated with China Cultural Revolution and National Agricultural Policy has diminished the ability of catchment on absorbing excess rainfall thus increased the runoff. Anthropogenic disturbances were also identified contributing to the severe water loss due to less rainfall after 1992 and early 2000s. Since 1992 dam has constructed extensively along JRW as well as in the early 2000s, when the economic sector shifted from agricultural into industrial lead to the elevated water intake demand. This study revealed that streamflow become more vulnerable to climate changes under intensive anthropogenic disturbances within coastal watersheds.
Developing and Implementing a System to Manage Operational Risk and Increase Reliability of Water Supply with Recycled Water added to Reservoir Systems

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This paper presents the results of research, development and full scale testing of an operation and risk management system to increase reservoir (lake) yield with treated effluent from wastewater treatment plants and manage water quality. The introduction of treated effluent to a reservoir requires simulation of asset operation, maintenance and management of wastewater treatment plant for water quality. This includes analysis of periodic shut down of assets and parts of treatment system for maintenance. The treated wastewater quantity and quality are coupled with variation of demand for drinking and irrigation waters from the reservoirs to optimize maintenance.

At this time, the system is being applied to Santa Rosa, California. Following four consecutive years of low rainfall as part of what may be the worst drought in 1000 years (despite highest recorded rainfall in December 2014), there is a need to augment drinking water supply from rivers (Sacramento-San Joaquin rivers) with recycled water that has to be stored in reservoirs (surface and groundwater reservoirs). In Santa Rosa, the objective is to store and reuse entire effluent from 100,000 m3/d plant for water supply, irrigation and power generation.

A similar need exists in Virginia, where Fairfax Water augments its supply from Potomac River with water drawn from Occoquan reservoir. A parallel research effort, presented separately, may show that water supply to Occoquan reservoir is periodically dominated by recycled water from UOSA plant.

The system allows one to simulate water quality, manage risks and optimize water supplies. It does this by optimizing operation and management of assets at the treatment plant based on reservoir storage capacity and need for water supply. TDS-salinity, soluble slowly biodegradable COD from pharmaceuticals, which affect reservoir water quality, are added to TSS, organics and nutrient removal simulations in the IWA model for wastewater treatment.
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Bubble Plumes for Lake and Reservoir Management

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Bubble plumes, from direct injection of compressed air or pure oxygen, have become more prevalent in lakes and reservoirs in recent years, with applications including destratification, aeration, hypolimnetic oxygenation, creation of fish habitat, water quality enhancement, algae control, and hydropower release improvements. A very wide range of bubble plume strengths, gas type and diffuser distributions provide the means to achieve success in a host of different situations. Improved modeling capability and extensive verification in the field has facilitated bubble plume design for very specific placement of oxygen. This presentation will show how bubble plumes can be modeled and how diffuser systems can be designed and operated to achieve a wide range of specific results. The presentation will highlight bubble plume applications that provide a comparison of model predictions and field results. These applications range from weak plumes for efficiently placing oxygen over sediments to strong plumes for reservoir destratification. The presentation will include results from J Strom Thurmond Reservoir in South Carolina, Spring Hollow Reservoir in Virginia and Lake Hallwil in Switzerland.

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Modelling of projected direct effects of climate change on water quality in Mount Bold Reservoir.

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Global climate change may result in increased risk of poor water quality in drinking water storages associated with climatic phenomena (cyanobacteria, iron and manganese, turbid inflows, pathogens). We describe progress towards an integrated modelling scheme using downscaled climate data, catchment and reservoir models. Here we focus on downscaling and direct impacts on water quality in Mount Bold Reservoir, South Australia, as modelled using the General Lake Model. A nonhomogeneous hidden Markov model (NHMM) downscaling dataset of meteorological variables (air temperature, precipitation, relative humidity, solar radiation) was extended (wind speed, cloud cover) to use in conjunction with reservoir models. Wind speed was downscaled by fitting Weibull or gamma distributions to daily wind speed observations, conditional on the month and prevailing NHMM state; these distributions were then conditionally sampled to generate the meteorological time series. Cloud cover was predicted from the difference between daily solar radiation and the calculated daily clear sky radiation and published relationships. Consequently, no trend in wind speed was present in the downscaled data set, while the downward trend in cloud cover was derived solely from projected changes in solar radiation. Catchment fluxes of constituents were kept constant between scenarios, allowing the evaluation of direct effects of climate change on reservoir water quality. Ensemble projections (>12 GCMs) of model outputs for three future periods (2011-2040; 2041-2070; 2071-2100) and two emission scenarios (RCP4.5; RCP8.5) were compared to the period 1961-1990 with historical forcing, with summaries calculated on a monthly basis. In the future climate scenarios, surface water temperature and stratification, salinity, dissolved organic carbon, particulate organic carbon and cyanobacterial abundance increased, whereas dissolved oxygen, green algal and diatom abundance decreased. The magnitudes of the projected changes are discussed with regards to potential adaptation actions and the likely contribution of catchment impacts.
Modelling circulation of Cl in Lake George, NY, USA with hydrodynamic and water quality models

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The Jefferson Project is a collaboration among Rensselaer Polytechnic Institute, IBM, and The FUND for Lake George, aimed at understanding and managing complex factors (road salt, storm water runoff, invasive species) threatening Lake George, New York. Lake George is located about 80 km north of Albany in upstate New York, USA and is known internationally for its water clarity.

The rising concentration of salt (NaCl) used to control winter road ice has been identified as one of the main threats to water quality of the lake, because salt in lakes may affect their physical and biological processes. The fate of chloride (Cl-) and sodium (Na+) is controlled by their reactivity in soil and their hydrodynamic transport. Elevated Na from salt is partly adsorbed by soil, thereby desorbing other ions (Ca2+, Mg2+, H+, and Al3+), the latter two only at low pH. This lowers the Na/Cl ratio from salt that reaches the lake to <1. Chloride is relatively non-reactive in soil, being only very weakly adsorbed and forming minor complexes with solid organic matter. Additional Na and trivial amounts of Cl are contributed from chemical weathering. Small contributions of Na and Cl from atmospheric deposition are dwarfed by road salt applications. Hydrodynamic transport of Cl and Na includes surface and groundwater flow, and advection, diffusion, and turbulent mixing in the lake’s water column.

In this work a 3D circulation model of the lake is developed to simulate the circulation of Cl; forcing is by a combination of local public survey data for the water budget and atmospheric data from the NWS (NOAA National Weather Service). The model is then used to simulate the fate and transport of Cl.
Next steps in reservoir monitoring and modeling: Connectivity and Actionable Visualizations

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For over 40 years Occoquan Laboratory in Northern Virginia has been monitoring the Occoquan Reservoir and its tributary watershed. With the reservoir modeling program, an effort to simulate the reservoir conditions has also been underway for over two decades. The data collected by field observation and assembled as outcome from the modeling effort is typical of several other reservoir monitoring and modeling programs which include depth profiles. Over last few years, the Occoquan Laboratory has undertaken an experiment to make its data available to the stakeholders in the region using a web-based portal. To develop this portal a database schema was designed to store such data, vocabularies were developed to standardize data sharing, and web-based visualizations were programmed to assist with data interpretation. This talk will discuss some of the hurdles faced and lessons learnt while developing such a portal. Also, we will discuss the idea that to extend the benefits of such a system and connect data available in different lakes and reservoir management organizations, it is essential that reservoir modeling and monitoring community should work towards developing standard ontology and modeling language that describe data collected and facilitate data sharing.

3D Modeling of Hydrodynamics and Residence Time on Cayuga Lake’s Southern Shelf

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Cayuga Lake is long (65km), narrow (3km), and deep (130m max). A shallow shelf (<6m deep) extends 2km north from the south end. Concern about phosphorous and sediment loading has initiated an effort to understand the physical processes that control water residence time (WRT) on the south shelf. Sources include two major tributaries dominated by erosion and agricultural loading, two wastewater treatment plants, and a deep lake cooling facility. Shelf hydrodynamics are controlled by point sources and wind-induced circulation, modulated by stratification and the earth’s rotation. To investigate how these phenomena determine shelf WRT, we incorporated a near-field point source model based on CORMIX into the 3D hydrodynamic model Si3D. This tool is calibrated using field temperature transects and remote flyover images, and validated using field data from deep water temperature strings, shelf temperature data, velocity data, and monitoring from herbicide treatments. Simulations based on observed forcing are used to characterize shelf WRT, and simulations based on hypothetical forcing are used to investigate the relative importance and interaction of different hydrodynamic processes.
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**A generalized understanding of the total solid content effect on anaerobic digestion**

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The efficacy of anaerobic digestion was found to increase with the total solid content (TS) loaded into digesters until a threshold of TS between 15% and 20% is reached, beyond which the efficacy just monotonously decreased with further TS increase. Yet, the reason behind was not understood. To address this unknown, mesophilic anaerobic digestion was carried out in a 20-channel respirometer with TS ranging from 2% to 40%. Kinetic modeling was utilized as a tool to analyze the profiles of the biogas production in response to various TS loading. This is probably the very first study that has employed a respirometer to delineate the kinetic behavior of anaerobic digestion under varied TS environment. It is anticipated that results of this study in conjunction with the findings from our previous research will help comprehend the TS-influenced anaerobic digestion, and aid in elucidating the mechanism behind the predominant role of TS in the determination of anaerobic digestion efficacy.

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**Uncertainty in Climate Change Impacts on Basin-Scale Freshwater Resources in Northern Virginia**

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Studies have shown that the climate has changed adversely due to the human activity over the 20th century. Recent studies have shown that climate change can affect the statistical properties of precipitation (e.g. depth and intensity), and the design statistics such as intensity duration frequency (IDF) relationships are subject to change under future climate. The change in frequency of precipitation will directly affect the peak discharge and the total volume of runoff. As a result of alterations in the future precipitation and temperature, hydrological flow regimes will be changed. Therefore, a detailed study is required to evaluate the effects of changes caused by climate change and land use change and their consequences.

The primary focus of this study is the Upper Broad Run subbasin in the Occoquan Watershed, which itself is part of a bigger watershed known as the Potomac River Watershed. Different climate scenarios along with two different Global Circulation Models (GCMs) have been used to understand the uncertainty within the future climate change in the study area. Using 8 different climate models and GHG scenarios for mid and late 21st century, indicates that there will be on average 25% and 42% increase in the maximum and median flow in the study area, respectively.

The results of this study will benefit stakeholders for future planning and developing strategies to operate and optimize the water storage, treatment and supply systems.
Singapore Experience on the Importance of the Reservoir Turnover on Water Quality

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Reservoir turnover, which is governed by various inflows to and outflows from reservoirs, is carried out in conjunction with water treatment processes. However, it also has an impact on reservoir water quality. In Singapore, reservoir inflows include rain water from direct water catchment, inter-reservoir transfer, injection of NEWater for indirect potable use, and abstraction from indirect water catchment via stormwater collection ponds. As for reservoir outflows, these include transfers to other reservoirs, pumping to waterworks, reservoir scouring, and discharge through tidal gates.

Reservoir turnover can in fact be an important strategy in managing reservoir water quality, and is often initiated when reservoir water starts to decrease in quality. This presentation will share two case studies on the importance of reservoir turnover on water quality. For case study 1, high total organic carbon (TOC) was observed in Pulau Tekong Reservoir, which is located on Pulau Tekong Island in Singapore’s north-eastern coast. This reservoir experiences high TOC level mostly in drier periods. The TOC level could be reduced by managing the reservoir stock and scouring operation strategically. Case study 2 is high chlorophyll-a (Chl-a) level in Pandan Reservoir, which is an elevated reservoir in the western region of Singapore. The pattern between turnover and Chl-a, although less clear, showed general trends that Chl-a tended to increase when turnover rate (total water outputs over reservoir volume) was higher than dilution rate (total water inputs over reservoir volume). The Chl-a tended to decrease when both turnover rate and dilution rate were high.

Reservoir turnover could thus help to maintain and improve reservoir water quality. However, it remains a challenge to maximize the benefit of turnover due to other operational constraints (e.g. weather, water supply demand, water quality, etc.), and this requires constant review for improvement.
An integrated modeling approach to improve the reuse and reliability of water supply systems

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The Occoquan reservoir in Northern Virginia is formed by the confluence of the Occoquan River and Bull Run. It is a key water supply source for Fairfax Water. The Upper Occoquan Service Authority (UOSA) water reclamation plant discharges directly into the lower Bull Run subbasin, which drains into this reservoir. Optimum operation of water reclamation facilities (WRF), such as UOSA, is critical for water supply systems especially when the reclaimed water constitutes a major portion of the safe yield of the reservoir. As population grows and fresh water availability varies as a result of climate change, the need for timely and reliable decisions related to plant operations becomes greater. Reliable operational strategies can be derived from advance modelling techniques to alleviate future risks associated with water availability and quality without needing high levels of financial investment.

To develop a better understanding of such scenarios, IViewOps (www.aquifas.com), an intelligent process simulation platform, has been implemented at the UOSA plant to evaluate current and future operations, and optimize plant performance. This paper will present how IViewOps, coupled with the existing Occoquan watershed model (a linked system of seven HSPF and two CE-QUAL-W2 applications), will be capable of simulating the complex interaction of the entire water supply chain. The resulting application will be used to identify and analyze strategies to manage the UOSA WRF performance dynamically in response to weather patterns and include reservoir monitoring data as part of the IViewOps display at the UOSA WRF control room. It is envisaged that this will provide stakeholders a tool for water resource contingency planning, risk assessment and a holistic view of the potential improvements in various components of the water supply chain, with the future addition of Fairfax Water’s Occoquan treatment plant also using IViewOps.
Coupling watershed and reservoir models to assess the impacts of climate change on the water quality of an off-channel reservoir in a humid-subtropical climatic region

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This study assesses the impacts of climate change on the water quality of Hsinshan Reservoir, a small-deep, off-channel drinking water reservoir located in northern Taiwan, by coupling the simulation results from the Hydrologic Simulation Program Fortran (HSPF) and the CE-QUAL-W2 model. Parameters of the coupled watershed-reservoir model were calibrated by field data collected during 2004-2008, and verified against observations made during 2009-2012. The HSPF model was additionally calibrated using data collected from three storm events to better quantify the influence of non-point source pollution. The projected temperature and precipitation data for the near- and long-term future were downscaled to regional and daily scales, and used to simulate the projected changes in water quality through the validated model. The simulation results were organized and reported as probability-based cumulative distribution functions to access the impacts of climate change on water quality. The preliminary results indicate that the intensified thermal stratification caused by the rising temperature is the primary driver of the decline in reservoir water quality, which increases the probability of deep-layer oxygen depletion and the flux of limiting nutrients for algae growth, resulting in a higher risk of algal blooms and eutrophication. The adaptation strategies of multilevel-intake operations and increasing bottom-layer dissolved oxygen without destratification are recommended. In addition, the results show that the quantity and quality of the recharge water pumped from the off-site catchment has inevitable impacts on risks to the reservoir quality due to a greater frequency of more intense rainfall events in the future. Short-term measures include enhancing water quality monitoring of the pumped water and developing operation procedures indicating the appropriate timing, quality or amount of recharge are also suggested.
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The Jefferson Project at Lake George: Advancing our ecosystem knowledge of an oligotrophic lake through a coupled observatory and environmental modeling system.

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Taking a holistic approach to understanding large lakes requires spatially and temporally extensive data on the relevant physical, chemical, and biological parameters that drive ecosystem function. With this goal in mind, we will describe a new collaborative endeavor, known as the Jefferson Project, which involves a complex environmental monitoring and modeling system capable of real-time observations and interactive modeling of weather, hydrology, hydrodynamics, and food web dynamics. The Jefferson Project began by conducting a state-of-the-art bathymetric survey of the lake and an associated topographic survey of the surrounding watershed. We then developed an advanced cyberphysical system that encompasses multiple sensor platforms and a tightly integrated cyberinfrastructure that utilizes high-integrity telemetry, embedded and distributed intelligence, and a comprehensive information platform. These sensor platforms quantify physical, chemical, and biological parameters and initial findings will be reviewed. To ensure the highest levels of data integrity and quality and to support dynamic event-driven autonomous operations such as adaptive sampling techniques, we have also developed a number of new approaches and technologies. We will also present the latest results of our weather, hydrological, and hydrodynamic models as well as the integrated and complementary experimental plan at the lake and mesocosm level to examine the underlying mechanisms of interacting physical, chemical, and biological factors that determine lake ecosystem function.

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MODELING THE EFFECTS OF PURIFIED WATER DISCHARGES IN TWO SAN DIEGO RESERVOIRS

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Growth in San Diego, CA has put significant pressure on available water resources. Persistent droughts in the southwest and potential future climate change could further reduce water supplies to the area. The City of San Diego Public Utilities Department (City) is investigating the feasibility of recycling wastewater for potable reuse. In particular, the City has investigated the potential of recycling up to 83 million gallons per day (mgd) by having municipal wastewater undergo advanced water purification, and then routing the water to San Vicente (SVR) and Otay (OTR) Reservoirs. The reservoir’s water will be eventually used for potable supply. The three-dimensional Estuary, Lake and Computer Ocean Model (ELCOM), coupled with the Computational Aquatic Ecosystem DYNAMIC Model (CAEDYM), developed at the University of Western Australia, were applied to predict the reservoir’s water quality under various scenarios. SVR is a 247,000 ac-ft reservoir originally constructed in 1947; while OTR has a capacity of 46,700 ac-ft. Both reservoirs’ primary use is water supply; but they also support recreation and habitat for fish and wildlife. A model for each reservoir has been developed, and validated against in-reservoir and tracer study data. In the present application, the effects of augmenting the reservoir with purified water are investigated. In particular, the initial dilution and mixing of the purified water are quantified, with an emphasis on identifying and mitigating short-circuiting between the inflow and the outflow. The effects of the augmentation on the reservoir’s water quality, including salinity, algae, nutrients, dissolved oxygen, and pathogens are discussed.
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Non-chemical tools for removing of cyanobacterial blooms

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Chemical methods to control certain species of phytoplankton are well known, but have a side-ecotoxicological effects.

In our study we compare aeration-destratification systems which is running for 4 years with alternatives like the harvesting of cyanobacterial blooms biomass, ultrasound system and its effects on photosynthesis, hydraulic jet-cavitation, or the new system of proposed plasma induced reactor to removal of algal bloom. We have used several type of natural algal bloom (Microcystis, Planktothrix and Aphanizomenon) in our study.

Experimental results show the removal efficiency of cyanobacteria and the inactivation constant were increased with the increased time of application and with power of induced devices. The difference between species composition of natural algal bloom on their removal efficiency, was unobvious, but the effects of energy dedicated and repetitive rate on the inactivation of cyanobacterila bloom were significant. The changes in the visible spectra of cyanobacterial bloom solution demonstrated that photosynthetic pigments, such as chlorophyll-a, phycocyanins, carotenoids have been decomposed.

These results implicate that cyanobacterial blooms can be temporally inactivated by a physical-based tools demonstrating the considerable potential of such an alternative process for alternative water purification without any chemical treatment.

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Phosphorus recycling as the part of cyanobacterial blooms prevention strategies

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Current global reserves of phosphorus are expected to be exhausted in 50 years with consumption peak around 2030. Today, phosphorus is mostly obtained from mined rock phosphate and there is a lack of alternatives to substitute it. Main direction of phosphate application is focused on agriculture where it is used as fertilizer. It is necessary to find the opportunities for phosphorus recycling and reuse to assure food production using the fertilizer.

Phosphorus is not welcomed in the water environment in excessive concentrations, which can cause eutrophication and water bloom. Surface water pollution by phosphorus is caused via point and diffusive sources. Main point sources are municipal and industrial wastewater treatment plants. Although there are applied technologies to remove phosphorus from the wastewater, phosphorus is then attached in the flocks where it is in not bioavailable form (in the case of precipitation by ferric or alum salts) or it is in the biomass containing high concentrations of heavy metals and therefore not recyclable in the agriculture. Alternatives for P-removal and P-recycling will be compared and the ecological and economic consequences will be discussed.
A Coupled Water Jet - Hydrodynamic Model for Predicting Oxygenation in a Eutrophic, Shallow Reservoir

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Controlling hypoxia in water bodies plays a key role in water quality management, especially for the hypolimnetic waters where the dissolved oxygen concentration can easily go below a critical value for water quality (usually 2 mg/L). Maintaining a substantial oxygen concentration in the bottom waters may suppress the release of nutrients and reduced metals, thereby preventing water-quality problems. The study site is Falling Creek Reservoir (FCR), Virginia USA. FCR is a small, eutrophic drinking water reservoir with a maximum depth of 9.3 m, and is operated by the Western Virginia Water Authority. Despite its small size, FCR can have stable thermal stratification during the summer period, producing suitable conditions for hypolimnetic oxygenation. However, FCR has also exhibited summer cyanobacterial blooms associated with a series of problem including hypolimnetic anoxia.

To cope with the problem, a side stream supersaturation (SSS) system has been deployed to add oxygen-rich water into the reservoir and mitigate water-quality issues. This study will introduce a three-dimensional hydrodynamic model coupled with a newly-developed water jet model so that the dynamics of water flows, water temperature and oxygen concentration in FCR can be simulated and studied.

The present study has identified that the operation of the SSS system can successfully increase the oxygen concentration in the hypolimnetic waters. The process weakens the thermal stratification and the hypolimnetic water is slightly warmed up due to the mixing. But the extent to which the water is destratified is smaller than that caused by bubble plume systems. Consistent trends are found in the results from the field observation and numerical simulation. The study also shows that, in order to reduce mixing further, the water flow rate out of the nozzle can be reduced, or the nozzle angle can be made horizontal.
Automatic Monitoring Systems for Continuous Water Quality and Flow Information during Storm Events

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Increase of imperviousness in watershed area increases delivery of water flow, sediment and pollutants to surface waters. During storm events, pollutants accumulated on the surface and in combined sewer systems can be flushed to surface water bodies and cause water quality problems. While it is essential to find out information on water and pollutant behavior during storm events for their effective management, it is very rare to find such data due to random nature of storm event occurrences and large cost of labor and equipment. Also it is not possible to monitor every water quality variable necessary for problem identification using field sensors and it is even rarer to monitor flow data simultaneously.

Automatic water quantity and quality monitoring station have been developed and tested in the Gwanpyung-Cheon, a small urban stream in Daejeon, Korea to acquire to achieve above written purposes. The monitoring system consists of pump, water quality sensors, automatic sampler, rain gage and ultra sonic water level meter. Few items including dissolved oxygen, conductivity and etc. can be measures using sensors and programmable automatic sampler can collect water sample according to predesigned time intervals. It was successful to obtain realistic waste loads information including hydrograph and pollutograph during storm events and it is expected that this system can be used for development and management of many water quality and quantity management projects.

The Role of Auxiliary Reservoir on Effective Water Supply in semi-arid climate

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In this study for efficient water management at small irrigated farm an optimal water release of the auxiliary reservoir based on prioritization in water allocation to the crop sensitive growth periods was linked to a non-linear optimization model in order to enhance the net income in a given cropping pattern. The proposed model by optimal water allocation for each growth stage of the crop reduced the impact of the imposed water stress in the dry season and increased the net income. The LINGO software has been used to evolve the optimal amounts of both water and land for the existing crops. The proposed model was applied for Razmgan area a semi-arid region which is located 10 km south of the Shirvan city, northern Khorasan province, Iran. Results shows that in optimal case, existing water deficiency during July, August, September, October and November is vanished. However water deficiency remains about 13% in May and 42.16% in Jun. Also, by using the proposed model annual net inflow can be increased about 26.21%. Moreover, in optimal condition the total water consumption is decreased about 10.71% compare to the current situation.
Development and Application of BIWA-3D Model for Lake Water Quality Assessment using Satellite Image

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Lake Biwa is the largest freshwater lake (674 km²) in Japan, supporting more than 15 million people and holds both social and economic importance. Due to rapid urbanization and industrialisation, eutrophication in the lake aggravated from past few decades. In this study, BIWA-3D model (unix based 3-dimensional circulation model) was developed and applied to assess and predict the Lake Biwa water quality for the year 2010-2014. The numerical simulation of water quality parameters mainly Chlorophyl-a (Chl-a), water temperature (T) and dissolve oxygen (DO) was performed with 250 m horizontal grid spacing in the model. The calculated model results showed good agreement with the water quality field observation data provided by Lake Biwa Environmental Research Institute (LBERI). However, study also aims to determine the feasibility of using satellite image (using ENVI) for verifying the model results, focusing on chlorophyl-a concentration. Therefore, Terra Moderate Resolution Imaging Spectroradiometer (MODIS) satellite image (250 m resolution), was used based on which the regression model developed (R² > 60 and p ≤ 0.05) between water quality observed data (+ 5 day satellite overpass) and MODIS satellite image (band reflectance). Based on this correlation the chlorophyl-a concentration was mapped using Arc-Map 10.1. The visual image obtained from the numerical simulation of chlorophyl-a from Biwa-3D model, showed satisfactory result when compared with the MODIS chlorophyl-a concentration map from Arc-Map.

The study indicates the successful application of BIWA-3D model for predicting lake and estuaries water quality. The use of remote sensing approach also offers the spatially continuous estimates of chlorophyl-a and other nutrient concentration for lakes. However, the model is currently extended for its use in Lake Toba in Indonesia along with some modification to estimate the impact of climate change on lake water quality.

Eutrophication of Lake Victoria in East Africa: a case study in Kenya

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Lake Victoria is the second largest freshwater lake in the world and the largest tropical lake with a surface area of 68,000 km² (average depth of 40 m and maximum depth of 79 m). The Lake is shared between Kenya, Uganda, and Tanzania, which controls 6, 45, and 49 %, respectively. The Lake has a catchment basin area of 195,000 km² which includes Rwanda and Burundi. Lake Victoria is of great socioeconomic significance to the riparian states as it is the major source of water for domestic, agricultural, and industrial purposes. We analyzed the water quality of Lake Victoria in Kenya from 1999 to 2012. The concentrations of nitrate nitrogen (NO3-N), soluble phosphorus (PO4-P), chlorophyll a, and Secchi transparencies of Lake Victoria in Kenya waters were evaluated as key water quality parameters. It was found that the water quality of Lake Victoria has been deteriorated in recent years, with eutrophication a serious problem. This was confirmed by an increase in aquatic vegetation using an analysis of moderate resolution imaging spectroradiometer (MODIS) images of 2000 and 2012 of Kenyan waters. We also analyzed how nutrients from agricultural non-point sources contribute to water resources pollution. We conclude that the current basin management practices are not effective for water resources protection. An integrated water resource management strategy is necessary for the protection of water quality in Lake Victoria.
Assessment of Heavy Metal Contamination and Accumulation in Sediment and Macrophytes of Hongze Lake, China

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Aquatic macrophytes are unchangeable biological filters and they carry out purification of the water bodies by accumulating dissolved metals and toxins in their tissue. The concentrations of heavy metals (Cd, Cr, Cu, Ni, Pb, and Zn) in soil and macrophytes collected from different locations of Hongze Lake, China were investigated. While total soil Cd, Cr, Cu, Ni, Pb, and Zn concentrations varied, respectively, from 0.09 ± 0.24, 57.5 ± 98, 9.72 ± 80.5, 14.3 ± 40, 14.2 ± 28.3 and 36 ± 155 mg-kg⁻¹, those in macrophytes ranged from 0.035 to 0.49, 2.91 to 75.6, 4.79 to 32.4, 1.27 to 16.1, 0.62 to 10.2, 18.9 to 84.6 (mg-kg⁻¹), respectively. Among the macrophytes most of the species were efficient to take up and translocate more than one heavy metal from roots to shoots. The analyses of these macrophytes have shown the importance in accumulation of heavy metals and maintaining the clarity of water bodies. This aim was to define the level of pollutants in Hongze lake and understanding the importance of these aquatic macrophytes in accumulation of toxic metals and to evaluate whether these species could be useful for the preservation and restoration of ecosystem.

Key words: Hongze Lake, Macrophytes, Sediments, Accumulation, Toxic metals

Effects of Aquatic Environment by the Distinct Enclosure in the Tai Lake Basin

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In the distinct enclosure experiment, based on the evaluation of the eutrophication of China’s lake (reservoir), the annual average eutrophication index (EI) of the 4 sections in this experiment was 62.26, and all of the 4 sections were of moderate eutrophication; according to the phytoplankton cell abundance evaluation, the annual eutrophication level of the natural lake area was high eutrophication, the water intakes of Gonghu Waterworks moderate eutrophication, the enclosure-leading area high eutrophication and the in situ experiment area moderate eutrophication. The water of the intakes of Gonghu Waterworks was superior to that of other regions in many aspects, including water quality, phytoplankton, zooplankton and eutrophication evaluation. Therefore, it can be assumed that the enclosure and wetland restoration works in Gonghu Bay have exerted positive effects on Gonghu Waterworks.

No nutritional limiting factor for phytoplankton growth was found in the distinct enclosure experiment, but significant correlations existed among water quality, phytoplankton and zooplankton, and there were obvious bottom-up effects among them. As for water quality status, significant linear correlations existed among water temperature, pH value, turbidity, dissolved oxygen, total nitrogen and ammonia nitrogen, and between Chl-a and phytoplankton density. Phytoplankton density was shown to be highly linearly correlated to zooplankton density and biomass. Linear regression equation: zooplankton density = 247.24 + 0.91 * phytoplankton density; zooplankton biomass = 1.09 + 0.003 * phytoplankton density. The enclosure experiment is conducive to the restoration of the health food chain relationships.
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**Influences of Land Use on Sediment Pollution across Multiple Spatial Scales in Taihu Basin**

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The dynamic relationship between land use and sediment pollutants in plain river network area were explored at multiple spatial scales. In our study, semi-circle buffers (100, 200, 500, 1000, 1500 and 2000 m) was drawn to represent six spatial scales. Multivariate analysis, including principal component analysis, Pearson’s correlation analysis and stepwise regression analysis were used to detect the characteristic spatial scale of non-point source pollution in Taihu Basin. The results suggested that paddy field, rural residential, build-up and vegetation are the most important indicators for sediment pollution variability, and sediment pollution was influenced by integrated effects of land uses. The same type of land use could produce different pollutant concentration. The impacts of anthropogenic land use on sediment pollution might have different characteristic spatial scale, e.g. 500 m buffer scale was identified as human disturbances spatial critical scale for TN, Hg, Pb and Zn, 1000 m buffer scale for Cd, Cr and Cu, 1500 m buffer scale for OM, and TP was significantly influenced by human activities in 1000 ~ 1500 m. We concluded that the 1000m buffers on both sides of rivers which considered as the existing priority areas for environmental protection are not very effective in Taihu Basin and expanding the priority regions is therefore crucial to optimize their effectiveness. The identification of the characteristic spatial scale of anthropogenic disturbance could provide new ideas for water environmental protection management in Taihu Basin.

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**Variation of Algae Colonies in One Southern Reservoir of China**

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The artificial reservoir had been completely constructed in Jan. 2009 and put into use from Oct. 2010. Now it provides more than 10 million persons drinking water in Shanghai and the hydropenia situation for poor water quality has been improved. Changes of algae colonies and Oscillatoria community structure for the past four-five years in one reservoir at different operation stages were investigated and the results display: 1. The total algae amounts was about 10^6-10^7 cells/L in the first four to five years of operation under the current dispatching method, kept lower in spring and winter, higher in summer and autumn. 2. Oscillatoria was not dominant population, and showed wide temperature adaptability in the reservoir up to now. 3. Migrationes occurred withiby the scheduling operation about main detection areas and amounts distribution of Oscillatoria, which was from upper and middle reaches to whole reservoir, finally to middle and lower reaches.
Effect of Chlorination on the Cell Integrity and Metabolites Release and Degradation for Colonial Microcystis

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The occurrence of toxic cyanobacteria in drinking water sources is problematic for water authorities as they can interfere with water treatment processes. Chlorination as a commonly used oxidant in water treatment strategies has shown the potential to lyse cyanobacterial cells, resulting in release of toxic metabolites and odorants which are hard to be removed in conventional water treatment processes. The most of previous studies have mainly focused on the influence of chlorination on the single cyanobacterial cells. However, the majority of cyanobacterial species such as Microcystis, often present in colonial forms under natural conditions. A fluorescence technique, combining SYTOX Green nucleic acid stain with flow cytometer, was successfully developed for the determination of cell integrity for colonial Microcystis. A series of chlorination of Microcystis-laden water was conducted at different chlorine dosages for different colony sizes. A solid-phase microextraction (SPME) concentration followed by a gas chromatograph (GC) and mass spectrometric detector (MSD) was employed to measure an odorous metabolite, β-cyclocitral, while an enzyme-linked immunosorbent assay (ELISA) was used to detect a toxic metabolite, microcystins. The results showed that the colonial Microcystis was more resistant to chlorine than single cells. A Delayed Chick Watson Model describe the experimental data very well for the kinetic of cell rupture. The lag time and rate constant of cell rupture increased and decreased with increasing colony size, respectively. Chlorination also induced the release of microcystins from colonial Microcystis cells. The degradation of microcystins only occurred when enough chlorine was dosed. For odorant experiments, chlorine may inactivate β-carotene oxygenase and inhibit the production of β-cyclocitral. However, chlorine may also react with β-carotene directly to form β-cyclocitral, causing an increase of β-cyclocitral concentration with a longer reaction time.