

## **Evaluation of Metals That Are Potentially Toxic to Agricultural Surface Soils, Using Statistical Analysis in Northwestern Saudi**

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Heavy metals in agricultural soils enter the food chain when taken up by plants. The main purpose of this work is to determine metal contamination in agricultural farms in north-western Saudi Arabia. To this end, 57 surface soil samples were collected from agricultural areas. The study focuses on the distribution and geochemical behaviour of arsenic (As), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), mercury (Hg), lead (Pb), and zinc (Zn), and determines the enrichment factor and geo-accumulation index; multivariate statistical analysis, including principle component analysis, and cluster analysis, are also applied to the acquired data. The GIS method was used to prepare the metals and the enrichment factor spatial distribution maps. This study shows considerable variation in the concentrations of the analysed metals in the studied soil samples. This variation in concentration is attributed to the intensity of agricultural activities and, possibly, to nearby fossil fuel combustion activities, as well as to traffic flows from highways and local roads. Multivariate analysis suggests that Cd, Cr, Cu, Hg, Pb, and Zn are associated with anthropogenic activities, whereas Cr and As are mainly controlled by parent materials. Most of the studied metals are present in concentrations exceeding the permissible limits, with Hg and Pb being the most abundant.

## **Endophytes: An Indicator for Improved Phytoremediation of Environmental Pollutants**

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Phytoremediation has been described as an efficient medium through which chemical hazards that can be identified by various classes of pollution could be removed from the soil; hence it suffers various limitations that has prevented the field application of the technique. Plants lack the metabolic enzymes required for full pollutant remediation and this often results in slowing the pace at which phytoremediation activity occur. Such inherent limitation of plants for complete remediation of xenobiotic compounds calls for the idea to harness the effects of endophytic microbes in enhancing the degradation of chemical compounds that are found to be toxic. Various plants have been implicated in this new line of biotechnology. Whilst most of them defile the inherent limitations, others are affected by the challenges and therefore are unable to achieve the primary goal, which is environmental pollution remediation. This study provides an in-depth analysis of various endophytic-assisted phytoremediation studies on organic contaminated environment. It also highlighted the diversity of contaminant-resistant and degrading endophytes and the role of those microbes in maintaining a clean environment, providing explanations on how plant-endophyte relationship can be exploited for improved phytoremediation. Hence, the study proffered better alternative plants for phytoremediation of organic chemical contaminants based on the type of contaminant and the intending remediation protocol to be followed.

## Climate Warming Reduces Essential Fatty Acid Production in Algae

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Climate change predictions range from an overall warming of our planet to more subtle, regional, changes in the global distribution of surface air temperatures and rainfall patterns (IPCC 2014). Climate change is also associated with increased ocean salinity and acidity, increasing sea levels, intensification of coastal upwelling, and decreased lake levels. There is an urgent need to understand how life will be affected, at the biochemical level, in our warming world. For example, temperature is expected to have strong directional effects on the quantity and especially on the quality of fatty acids in algae and other microorganisms. The mechanism that explains this is called homeoviscous adaptation (the ability of cells to reduce the degree of unsaturation of membrane fatty acids in order to maintain a desired level of fluidity as temperature increases) (Sinensky 1974).

Algae fix carbon through photosynthesis into a vast array of compounds which are utilized by consumers. One such important class of compounds are essential fatty acids (EFA); compounds that animals cannot produce at all, or else produce inefficiently; so they must be supplemented from their diets. Examples include polyunsaturated fatty acids (PUFA) such as, alpha-linolenic acid (ALA; 18:3n-3), linoleic acid (LNA; 18:2n-6), and long-chain polyunsaturated fatty acids (LC-PUFA) such as, eicosapentaenoic acid (EPA; 20:5n-3), docosahexaenoic acid (DHA; 22:6n-3) and arachidonic acid (ARA; 20:4n-6). Freshwater and marine animals ultimately depend, to varying extents, on algae for access to these five EFA. An important, and not fully appreciated, threat posed by climate warming is that increasing water temperatures (through the process of homeoviscous adaptation) will reduce the global production of PUFAs in algae at the base of aquatic food chains. Such profound changes in the biochemical composition of algal cell membranes (Fuschino et al. 2011) are expected lead to cascading effects throughout the world's aquatic ecosystems. Furthermore, the repercussions of these biochemical and physiological cascades are also anticipated to propagate to land animals because of the flux of aquatic biomass (e.g. insect and amphibian emergence, fish taken by terrestrial predators) that routinely passes from aquatic to terrestrial ecosystems. This is critical because LC-PUFA not only enhance the growth rates and reproductive capacities of aquatic animals (Von Elert 2004; Ballantyne et al. 2003); they have also been shown to be of vital importance to the cardiovascular and neural/cognitive health of terrestrial vertebrates (Lands 2009).

Here we use a meta-analytic, regression-based, approach to examine the main effect of temperature on EFA profiles of green algae, diatoms, flagellates and cyanobacteria. Green algae, as a group, demonstrated a negative relationship between ALA and temperature. At the species level, the green algae *Tetraselmis suecica* and *Chlamydomonas reinhardtii* contained significantly less ALA as temperature increased. Diatoms, as group, had significantly lower levels of both EPA and DHA as temperature increased. At the species level, *Thalassiosira pseudonana* and *Nitzschia paleacea* had significantly less EPA with increasing temperature, and *Chaetoceros calcitrans* had significantly less DHA with increasing temperature. Both diatoms and green algae generally showed a negative relationship with total PUFA and temperature, specifically the genera *Botryococcus*, *Chlamydomonas*, *Chaetoceros*, and *Nitzschia*. Conversely, while ALA, EPA, and

DHA tended to decrease with increasing temperatures, LNA, ARA and saturated fatty acids tended to increase with increasing temperature. For example, the diatoms *Chaetoceros calcitrans* and *Chaetoceros simplex* had higher levels of LNA as temperature increased. These findings transform our understanding of how climate-driven increases in water temperature may be affecting the production of EFAs in algae which form the base of aquatic food chains and which, in myriad interconnected ways, affect the health and vitality of all organisms.

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## **Histopathological Studies and Heavy Metals Accumulation in Water, Sediment and *Chrysichthys nigrodigitatus* at the Agiliti Iarea of the Ogun River**

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Heavy metals are considered as the most dangerous water contaminants because of their possibility of bioaccumulation and toxic effects. This study was aimed to investigate the bio-availability of heavy metals in terms of Zn, Cu, Mg, Mn, Cd, Cr, and Pb in the sediment and water for a period of six months (November 2012 to May 2013). And also in the fish (*Chrysichthys nigrodigitatus*) for a period of three months (April to May 2013). A toxicological study was also estimated to ascertain the effects of aquatic pollutants in the gills, kidney, liver and muscles of *Chrysichthys nigrodigitatus* for the period of three months (April to May 2013) at the Agiliti area of the Ogun River. Sediments were collected with the help of a grab and water samples with plastic containers. The fish was dissected with the help of a dissecting set. The water quality parameters were pH which has a mean of  $7.29 \pm 0.29$ , dissolved oxygen  $0.82 \pm 0.05$ , conductivity  $2.25 \pm 0.58$ , turbidity  $70 \pm 6.07$ , water temperature  $30.1 \pm 0.94^{\circ}\text{C}$ , air temperature  $30.9 \pm 0.94^{\circ}\text{C}$ , salinity  $1.54 \pm 0.94$ , transparency  $32.25 \pm 1.83$ , and depth  $344.50 \pm 10.92$  m. The result of the heavy metal analysed in the water sample can be represented as ( $\text{Zn} > \text{Mn} > \text{Mg} > \text{Cu} > \text{Cr} > \text{Pb} > \text{Cd}$ ) and that of the sediment can be represented as ( $\text{Mg} > \text{Mn} > \text{Zn} > \text{Cu} > \text{Pb} > \text{Cr} > \text{Cd}$ ), both indicated that there was no significant differences ( $P > 0.05$ ), while the result of the fish sample can be represented as ( $\text{Mg} > \text{Zn} > \text{Cu} > \text{Mn} > \text{Cd} > \text{Pb} > \text{Cr}$ ), it indicated that there was a significant difference ( $p < 0.05$ ). In conclusion, the heavy metal constituents present in both water and sediments are within the WHO limits. Therefore, the Agiliti area of Ogun River is less polluted and had insignificant effect levels in the accumulations of the concentrates in the tissues of the fish.

## Comparison of the Effect of Some Medicinal Plants Extracts on Germination and Growth of a Dicotyledonous Plant Lentils (*Lens Culinaris*) and Monocotyledonous Plant Maize (*Zea Mays*)

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A number of crops exhibit allelopathic interactions that play a significant role in the complex environment of agroecosystems. Several studies have shown that allelopathic crops reduce growth, development and yield of other crops growing nearby simultaneously or subsequently in the fields. Another aspect of interest regarding crop allelopathy is that allelochemicals may exhibit inhibitory effect on the same crop which is commonly called as *crop autotoxicity*. It is predominantly common in fields where sole cropping under reduced or no-tillage system is practiced. Though any crop part can be allelopathic, including even the pollens, but decomposing crop residues exhibit more influence on other plants. In the present study, the allelopathic effects of *Eruca sativa*, *Mentha peperina*, and *Coriandrum sativum* water extract prepared by grinding fresh leaves of the medicinal plants in distilled water and three concentrations were taken from the crude extracts (100%, 50% and 25% in addition to 0% as control) were tested for their effects on seed germination and some growth parameters of the dicot. *Lens culinaris* and the mononcot *Zea mays*. The experiment was conducted in sterilizes Petri dishes under the natural laboratory conditions at temperature of 25° C, with a 24h, 48h, and 72h, water (control, 0%). In lentils, germination percentage, reached 100% when treated with 50% and 25% *E. sativa* and 25% *M. peperina* extracts and reduced at 100% crude extracts of all plants. Radical and plumule length were increased at concentrations of 50% and 25% *C. sativum*, and 25% *M. peperina* compared to the control. Plumule fresh and dry weights increased at all *M. peperina* aqueous extracts compared to control, (%). In maize, germination percentage was suppressed when plants was treated with 100% extracts, however, 50% and 25% of *M. peperina* increased germination percentage by 4 times more than the control. Moreover, 50% and 25% extracts of *M. peperina* and 50% of *C. sativum* increased maize radicle and plumule length by 3 to 4 times that of the control. Results of plumule fresh and dry weights revealed that, concentrations of water extracts of 100% and 50% *M. peperina*, *E. sativa* 100% and *E. sativa* 50% reported almost similar plumule fresh weight as in control plants. The most interesting finding is the reduction in harmful salts and TDS which could be a good factor in saline soils of Saudi Arabia.

## **Developing Great Lakes Bioindicators of Environmental Conditions and Recovery from Degradation with Reference to Watershed-Based Risk of Stress**

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Environmental assessment typical entails comparing a biological characteristics at a test site to those of sites in the reference condition (the RCA), whose limits are determined empirically by sampling many reference sites. The reference condition is defined by physicochemical characteristics of 'best available' sites and associated biota. Test sites are then classified as 'equivalent to reference' (biota are not significantly different than a reference) or 'nonreference'. Applying the RCA is difficult when most of the study region is subject to varying degrees of disturbance. However, even when the Reference Condition is well defined, the relative status of 'failing' test sites (designated 'nonreference') is undefined because classification is binary.

The complementary 'degraded condition' is operationally defined as the set of sites whose physicochemical characteristics are deemed unacceptable by consensus (the 'worst sites in the system'). Consequently, any test site can be ordinated along a reference-degraded continuum (human disturbance gradient), and the site's relative quality (and associated biota) summarized by its position along the continuum.

We have analysed variation in assemblages of Great Lakes biota across reference-degraded continua at Great Lakes coastal margins to derive taxon-specific bioindicators (assemblages of birds, aquatic vegetation, fishes, aquatic invertebrates and diatoms). Titan threshold analyses of taxon losses or gains often identified 2 thresholds on the reference-degraded gradient. At one, many sensitive species disappeared, suggesting biodiversity loss; at another, tolerant taxa increasingly dominated. All assemblages were affected at approximately the same threshold, suggesting significant ecosystem functional alteration at these points. Composite indices can be calibrated to identify these critical points as "biological criteria". We propose that the non-degraded/degraded threshold be a suitable operational target to define the boundary between degraded and non-degraded conditions needed to delist Beneficial Use Impairments at Great Lakes Areas of Concern. The reference/non-reference threshold may be a suitable operational target to define the boundary between biodiverse and less biodiverse conditions.



## **Participatory Approach of River Conservation with Special Focus to Bagmati River, Nepal**

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A study on “Participatory Approach of River Conservation with Special Focus to Bagmati River, Nepal” was conducted during the period of June 2014 to April 2015 in Nepal in order to know the causes of pollution and remedial measures for the same. A stretch of Bagmati River from Gokarna to Minbhawan (15 km) was selected for field survey. Water samples from different five stations were taken in order to know the present status of water quality as the indicators of river pollution. Five monitoring stations were established along both rural and urban areas of the Bagmati River in order to find the quality of river water. Parameters such as DO, BOD, COD, and Turbidity were observed monthly. The turbidity and BOD were found to be in decreasing order and DO to be in increasing order. Similarly semi - structured questionnaire was prepared for social survey. The study showed that the degradation of Bagmati River was due to dumping of solid wastes in the river, discharging wastewater into the river, encroachment of floodplain area, open market, and improper management of waste materials after cremation of dead bodies. It was found that the cumulative effort like Bagmati Mega Cleaning Campaign for river conservation was being done. During mega cleaning campaign huge participation of volunteers was seen from different organizations. During field survey people also reported that there was huge politics on Bagmati River. Although millions of Nepalese rupees have already been invested for mega cleaning campaign, the river is still polluted. There are many ways of river conservation but the study has showed that the participatory approach is the most appropriate one in the context of Nepal.



## Effect of Oil and Dispersants from the Gulf of Mexico on Estuarine Fish Species

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The spill of the Deepwater Horizon oil into the Gulf of Mexico was the single largest input of oil to date into U.S. waters (4.9 million barrels; 206 million gal) (Azwell 2011) and was one of the first examples of the large-scale application of chemical dispersants to an oil spill (1.8 million gallons), an approved resource that will likely be used again. Since oil exploration and production in the GoM will continue, there will be risks of similar events potentially affecting the significant fisheries resources that exist in the area. These events will undoubtedly result in cleanup efforts similar to the ones that were performed after the DWH spill and there is consequently a pressing need to develop adequate measures to determine the sublethal effects of these types of exposures on aquatic organisms.

We obtained samples of Macondo oil and Corexit 9500 and 9527 for toxicity experiments. We weathered the oil and oil/dispersant mixtures in water by rapid stirring for 1 week in a fume hood using the methods of Hemmer et al. (2010). The water-accommodated fraction (WAF) of each test solution was diluted in artificial seawater and used to expose two species of estuarine fish (Sheepshead minnow, *Cyprinodon variegatus* and Menidia, *Menidia beryllina*). In survival tests with sheepshead minnow, we found that the addition of Corexit to the oil was more toxic than exposures to the oil by itself, decreasing the LC<sub>50</sub> by 20-fold, suggesting that the presence of dispersant increased the toxicity of the mixture, presumably by making the toxic components more bioavailable. Addition of Corexit 9527 to the oil at 1/10 the concentration of the oil prior to preparing the water accommodated fraction caused significant mortality of sheepshead minnows at concentrations of WAF from oil alone that were not lethal to the fish. The WAF from the mixture of dispersant and oil, called Chemically Enhanced Water Accommodated Fraction (CEWAF), was more toxic to fish than WAF. Columbia Analytical Services (Kelso, WA) analyzed chemical residue in each of the WAFs and found much higher PAH residue in CEWAF obtained from oil/Corexit mixtures.

Using sublethal concentrations of the WAF and CEWAFs ( $\Sigma$ PAH ~30 ppb) from oil, Corexits and mixtures thereof, we performed sublethal exposures of Menidia embryos and found developmental abnormalities (Fig. 1) including abnormal heart development, lower heartbeats per minute and edema, among others (Table 1). This is similar to what has been reported by Incardona et al. (2013) for other fishes and suggests a similar mechanism of action. These preliminary data suggest that exposure of sensitive estuarine species to oil and Corexit mixtures may lead to population level declines of Menidia in estuarine locations. Menidia, also known as silversides, inhabits estuaries along the Gulf coast. It has high ecological relevance to the GoM ecosystem, and is an abundant species in the salt marsh and in shallow waters. Menidia have demersal eggs, meaning that the eggs sink and are laid near shore, close to where oil was distributed near Louisiana marshes. They are widely distributed and are native to Eastern USA and the northern GoM and are important in the food chain for larger commercially valuable fish. It is an exquisitely sensitive life stage to environmental perturbations, including both natural stressors and chemical exposures.

Embryonic development is particularly important for all life forms since this is the life stage during which highly complex biological processes are directing rapid growth and cellular differentiation. Our results suggest that oil plus the dispersant may have adversely affected these fish in locations that were heavily oiled.

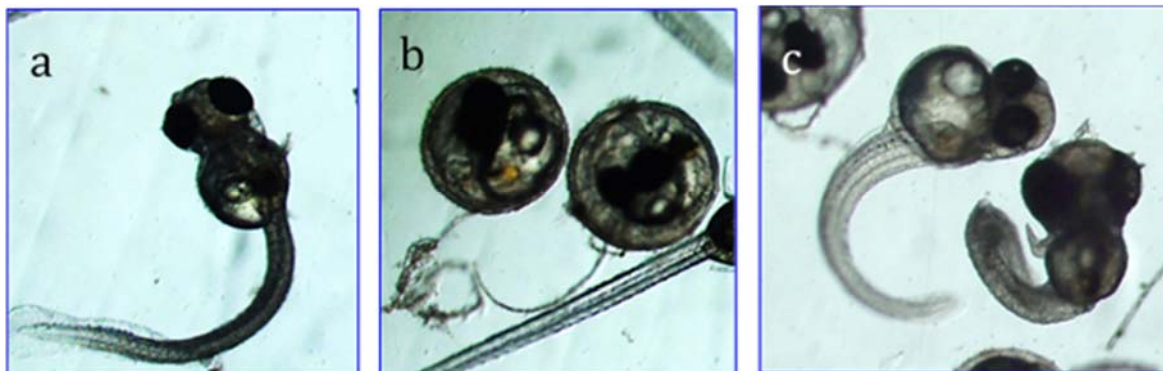


Figure 1. Skeletal and other morphological abnormalities observed with exposures of *Menidia* embryos to WAF and CEWAF. (a) skeletal curvature of the tail, (b) unhatched embryos showing signs of deterioration and (c) malformations of the head and pericardial edema.

Table 1. Diminished heart beats in *Menidia* embryos exposed to WAF from Oil, Corexit and a mixture of the two.

Condition	Heart beats measured	Deformities
Control	82.7 beats/min	None
WAF from Oil	80.25 beats/min	Skeletal abnormalities
CEWAF (Oil + Corexit 9527)	67.1beats/min	Unhatched embryo, Pericardial edema, skeletal abnormalities

The DWH oil spill occurred in 2010, but there is still a lot of controversy regarding whether the damage has been contained and whether there are still long lasting effects in this ecosystem. At the population level, marine species are resilient and after time recover from repeated insults, but there is probably some cost to these occurrences in terms of the fitness of the population. Along these lines we need to consider sublethal effects from oil and dispersant exposures that may manifest themselves in later generations as permanently affecting the fitness of a particular species.

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## Quantitative Biomonitoring of Water Quality for Pops Using Freshwater Mussels

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Mussels have a long history of use as freshwater and marine biomonitors of water quality. Under passive biomonitoring programs, organisms native to the region are collected from the site of study and contaminant residues measured in their tissues. Environmental quality can be inferred based on spatial patterns of measured tissue residues or in some cases estimates of water concentration extrapolated based on animal/water concentration ratios generated from bioconcentration factors. However, these programs may suffer from several issues. Study species may not be available in abundance at a given location due to excessive contamination or habitat characteristics. Organisms may not be in steady state with their environment with respect to tissue contaminant concentrations as a result of changes to environmental loadings. Lastly, sampling approaches may be difficult in some systems where depth, turbidity or flow conditions make diver assisted collections difficult or impossible.

In quantitative monitoring, animals of the desired species are obtained from cultures or a reference location and caged at the location of interest for set periods of time. This approach ensures that animals of the same species and in sufficient abundance are available at each location of study. Since the time of deployment is known in these cases, application of toxicokinetic models can be used to steady state correct time dependent concentrations measured in the biomonitor followed by estimation of water concentrations using bioconcentration factor approaches. Finally, borrowing methods used in passive sampler technologies (e.g. semi-permeable membrane devices), biomonitors can be pre-dosed with a set of hydrophobic, non-environmental chemicals designated as performance reference compounds (PRCs) prior to their deployment. By tracking the rate of dissipation of PRCs, mussel filtration rates are calibrated in-situ permitting the most accurate steady state correction and water concentration estimates. This seminar will highlight spatial and temporal observations generated from a long running quantitative mussel biomonitoring program implemented in the Huron-Erie corridor between 1996 and 2010. Spatial and temporal patterns of polychlorinated biphenyls are discussed as well as selected surveys where PRC compounds were used to track in-situ sampling rates in deployed biomonitors.

*Elliptio complanata* were collected each year from Balsam Lake near Lindsey, Ontario. Approximately 150 mussels from the reference location were transported to the Great Lakes Institute for Environmental Research, University of Windsor and held in recirculating tanks equipped with active charcoal filters for 2-4 weeks prior to deployment. Animals were placed in minnow traps or custom wire mesh cages equipped with a float and suspended off the sediment approximately 1 m. At some locations, cages were suspended from docks or break wall structures. Mussels were typically deployed for 21, 60-65, 126, 182, 220-250 d beginning in April/May until Nov-Dec each year. Samples were taken prior to deployment in order to measure day zero chemical residues for control correction. After a given deployment period, 5 replicate animals were collected

from cages at each sample location.

Standard sampling locations consisted of 6 locations in Canadian waters of the Detroit River utilizing an upstream/downstream sampling design in proximity to two sewage outflows operated by the City of Windsor. At selected years, additional locations were added to provide full coverage of water contamination for the Detroit River Area of Concern that included upstream, midstream and downstream waters in Canadian and United States jurisdictions. After deployment, mussels were frozen and analyzed for organochlorine pesticides and polychlorinated biphenyls using accredited standard analytical operating procedures via a CALA accredited laboratory.

Control and steady correction of contaminant residues in retrieved mussels was performed according to:

$$C_{(ss)} = C_{(t)} - C_{m(o)} \cdot e^{-k_{tot} \cdot t} / (1 - e^{-k_{tot} \cdot t})$$

Where  $C_{m(ss)}$  is the steady state corrected mussel concentration (ng/g wet weight) in the animal;  $C_{m(t)}$  is the chemical residues (ng/g wet weight) measured in the mussel at the time of retrieval,  $C_{m(o)}$  is the chemical residues (ng/g wet weight) measured in mussels prior to deployment,  $k_{tot}$  is the elimination rate coefficient ( $d^{-1}$ ) for each chemical of study and  $t$  is the time in days.

Water concentrations (ng/L) were estimated as:

$$C_w = C_{(ss)} / f_{lipid} \cdot K_{OW} \div 1000$$

Where  $f_{lipid}$  is the mass fraction of lipid in the shucked mussel sample and  $K_{OW}$  is the octanol/water partition coefficient (L/Kg) for the chemical of study.

Strong temporal patterns were evident in the 15 years of routine mussel biomonitoring collections (Fig. 1, A). Although extrapolated PCB concentrations showed no significant long term trends, multi-year periods of declines and increases in water residues were apparent and consistent across sample locations. Spatial patterns of PCBs in the Detroit River showed a significant increase in concentrations at U.S. locations compared to Canadian locations. The geometric mean U.S. concentration in 2002 was 0.64 ng/L compared to 0.9 ng/L in Canadian waters. In situ PCB toxicokinetics were found to be faster for deployed mussels compared to mussels depurated under laboratory conditions by a mean factor of 4 fold (Fig. 1, B). This indicates that use of laboratory derived elimination coefficients during steady state correction results in overestimates of water contamination particularly during short deployment periods. Uncertainty in estimates of  $C_{m(ss)}$  arising from variation in  $k_{tot}$  values across field locations and between replicate biomonitors is compared using model based Monte Carlo simulations to recommend optimum biomonitor deployment periods and replicate sizes.

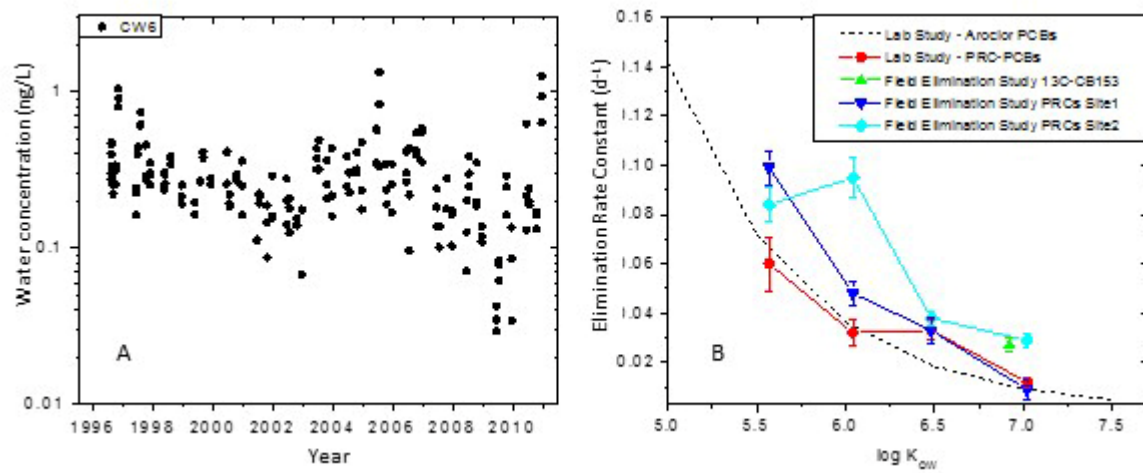


Figure 1. Temporal patterns of water concentrations at a biomonitoring station in the Detroit River from 1996-2011 (A). Comparison between in-situ elimination of  $^{13}C$ -PCBs and laboratory elimination of the same chemical by *Elliptio complanata* (B):

## Enhancing Biodegradation of Herbicides using Biobed Systems

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Agrichemicals such as herbicides and pesticides are released into the environment by accidental spillage from spray tanks during mixing or cleaning processes, causing point-source contamination where these chemicals are handled. A cost-effective way of treating such contamination is biobed technology. A biobed is a lined structure filled with a mixture (biomix) of topsoil, a peat substitute and straw. The biomix retains the pesticides for a period of time and gives a chance for microbial degradation to occur, thus reducing the potential contamination of ground and surface waters. Although on-farm biobed systems have been successfully developed and used in several European countries, adaptation must be made before they can be constructed under Missouri climatic conditions.

The overall goal of this study was to develop a biobed system that adapts to the soil and environmental conditions of Missouri to treat and dispose of selected herbicide wastes; and gain understanding of biobed technology and its potential application to prevent the movement of pesticides through soil to surface and ground waters. Specific objective was to test suitable biobed materials that can enhance degradation of different herbicides, and identify optimal biomix ratio for enhancing herbicide degradation.

Top soil samples were randomly collected from multiple points in a hay field at the Lincoln University Carver Farm. The soil was a Wrengart silt loam (fine-silty, mixed, active, mesic Fragic Oxyaquic Hapludalfs). Soil samples, chopped wheat straw, peat and garden waste compost were mixed thoroughly at four different ratios (Table 1). Twenty-five grams of soil or biomix was placed in glass jars. A mixture of commercially formulated herbicides including acetochlor, atrazine, pendimethalin, triflurolin was added to each jar according to the highest recommendation value. Soil or biomix samples were kept at 60% water holding capacity. At day 3, 10, 20, 30, 60, and 90, three samples of each treatment were taken out. Samples were dried under room temperature, mixed thoroughly and extracted with ethyl acetate. Herbicide concentrations were analyzed using GC-MS.

Table 1. Composition and chemical properties of biomixtures.

Material	Straw: Soil: Peat/ Compost (%)	pH	Lignin Content (%)	C: N Ratio
Soil	Control	5.76	NA	8.5
Biomix 1	12.5: 62.5 :25(peat)	5.59	16.94	17.1
Biomix 2	25:50:25(peat)	5.78	19.67	22.3
Biomix 3	50:25:25(compost)	5.59	27.67	14.1
Biomix 4	62.5:12.5:25(compost)	6.13	26.85	13

Results indicated that different herbicide behaves differently in each biomixture material. Apparent recovery rate at 0 day ranged from 45% to 136%. Compare to biomix materials, soil has higher recovery rate for acetochlor and atrazine, probably due to stronger adsorption bonding in

biomix materials. Half-lives of herbicides are shown in Table 2. The half-lives for atrazine and pendimethalin in biomixtures were significantly shorter than in soil. The carbon to nitrogen ratios found in biomix materials were higher than that in soil, which better supported microbial growth for organic material degradation. Lignocellulosic materials such as straw and peat and compost stimulated lignin degrading enzymes such as phenol oxidase and peroxidase. Compost may be a cheaper substitute for peat in constructing biobeds. The results showed that biobed is effective in enhancing degradation of herbicides such as atrazine and pendimethalin.

Table 2. Half-lives of selected herbicides in biomixtures and soil.

	Half-life (days)				
	Biomix 1	Biomix 2	Biomix 3	Biomix 4	Soil
Acetochlor	5.9	5.7	6.4	5.7	6.7
Atrazine	15.7	10.0	15.0	16.0	35.2
Pendimethalin	12.0	9.6	9.6	13.8	43.1
Ttrifluralin	29.6	49.5	21.7	23.0	27.1



## **Agricultural Soil Profile Temperature in Hot and Arid Ecosystem: Can It Be a Useful Indicator Of Environmental Change?**

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Aridity is usually expressed as a function of rainfall and temperature. A useful "representation" of aridity is the following climatic aridity index: Precipitation/Evapotranspiration. The arid zone (arid index 0.03) comprises dryland areas without vegetation, with the exception of a few scattered shrubs and no farming except with irrigation. Annual rainfall is low, rarely exceeding 100 millimeters, with huge temporal variability. All these descriptions fill well climatic conditions of Kuwait and the larger Middle East region. Almost one-third of the total land area of the world is classified as arid land. Soil temperature change plays an important role in many processes which take place in the soil, and may change in response to atmospheric temperature fluctuations. Soil temperature warming is linked to atmospheric temperature increase through a complicated process of heat transfer. Consequently, soil temperature changes respond differently than atmospheric temperatures, because soil temperature fluctuation is regulated by multiple factors such as: heat capacity, albedo, leaf coverage, soil moisture and texture. Daytime temperatures can typically reach 45 °C during the "hot" dry season and drop to 15 °C during the night. High temperatures in the surface layer of the soil result in rapid loss of soil moisture due to the high levels of evaporation and transpiration. Deserts ecosystems are most sensitive to even small changes in environmental conditions to the extent that land use pressure has become so serious that dry land agriculture and natural habitats may be threatened in the long term. The primary objectives of this study were to: (1) quantify changes in temperature in the soil profile at different locations under different management practices in the state of Kuwait, and (2) examine whether or not soil temperature fluctuations follow a similar trend to air temperature fluctuations. The findings from this study represent original contribution to our understanding as it sheds some light on whether or not soil temperature changes can be used as a reliable indicator of global climate change.

## Bioactivity Effect of Two Macrophytes Extracts on Growth Performance of Two Bloom-Forming

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Aqueous extracts of two freshwater macrophytes; *Potamogeton pectinatus* and *Ceratophyllum demersum* with 50% and 100% each with acetone and ethanol solvents were tested on growth performance of two bloom-forming cyanophytes, *Microcystis aeruginosa* and *Oscillatoria tenuis*. The results revealed no significant difference between the overall total average growth performance at treatment with 50% and 100% *Ceratophyllum* acetone extracts expressed by optical density (OD) as well as chlorophyll a (chl a). They showed, both, stimulation of *Microcystis aeruginosa* growth. The highest growth increase in 100  $\mu\text{L}/100\text{ml}$  treatment with 50% acetone extract had percentage rate R, 94.66. On the contrary, treatment with ethanol extract recorded the highest inhibitory effect, thus in 1.5  $\mu\text{L}/100\text{ml}$  treatment with 50% *Ceratophyllum* ethanol extract R recorded -87.54, sustaining  $\text{LC}_{50}$  value 1.12  $\mu\text{L}/100\text{ ml}$ . The highest stimulating effect in  $10^5 \mu\text{L}/100\text{ ml}$  treatment with 50% *Ceratophyllum* acetone extracts against *Oscillatoria tenuis* was; R, 169.4. The highest inhibition in 1500  $\mu\text{L}/100\text{ml}$  treatment with 50% *Ceratophyllum* ethanol extracts against *Oscillatoria tenuis* was; R-74.32, with  $\text{LC}_{50}$  0.830  $\mu\text{L}/100\text{ ml}$ . While, the highest inhibition by 50% and 100% *Potamogeton* acetone or ethanol extracts against *M. aeruginosa* were in 80 and 70  $\mu\text{L}/100\text{ ml}$  treatments with R, -99.80 for both. There are significant differences between the overall averages for each solvent, both of 50% and 100% *Potamogeton* extracts against *Oscillatoria* as estimated by OD or chl a. The highest inhibitory effect for *Potamogeton* against *Oscillatoria* were in  $10^3$ , 800, 200 and 180  $\mu\text{L}/100\text{ml}$  using 50%, 100%, either acetone or ethanol extracts treatments, were R, -66.56, -73.24, -85.95 and -85.95, in return for  $\text{LC}_{50}$  932, 590, 129.50 and 101.428  $\mu\text{L}/100\text{ ml}$ , respectively.

## Gas Detection as Control Means of Microbial Metabolism in Biorefineries and for the Reduction of Environmental Emissions

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Microbiological cultures can be followed up on the basis of their gas emissions. We have used them for monitoring and understanding metabolic activities, interactions and microflora developments in the biorefineries. Gas flow can also be used for controlling the bioreactions. Besides numerous individual industrial projects, this approach was applied in the European Union Baltic Sea region ABOWE project (Advanced Concepts for the Biological Utilization of Waste), in its Pilot A movable unit (Fig. 1a). See also [www.abowe.eu](http://www.abowe.eu). Planning of the Pilot A was supervised by the author and his company, Finnoflag Oy, as the key technology providers. Microbiological process design was based on earlier research using the PMEUP device (Portable Microbe Enrichment Unit, Finnoflag Oy, Finland; Fig. 1) (Hakalehto 2011; Hakalehto et al. 2009).

One fundamental feature of the PMEUP is the adjustable gas flow. This gas flow can be an aerobic, microaerobic or anaerobic one. The volatile emissions into this flow can be effectively used for detecting and characterizing microbial cultures and communities in the enrichment containers in the PMEUP Scentrion®. These principles were transferred into a larger scale (200-300 liters of effective liquid volume) in the ABOWE experimental pilot station. There the incoming gas flow could be controlled and it was directed onto two levels as two different mixtures, if necessary (Fig. 1).



Figure 1. The ABOWE Pilot A (a movable biorefinery system) designed by E. Hakalehto. A: the interior; B: a patented bioreactor.

Amongst the emitted gases particular interest has been directed to hydrogen, which could be a remarkable energy reserve in the future. Practically all environmental microbiological suspensions and biomasses emit biohydrogen at some point. Its liberation can be detected also

from the human intestines, and during biotechnical runs. In Figure 2a the volatile emissions from Polish tests with Pilot A are introduced.

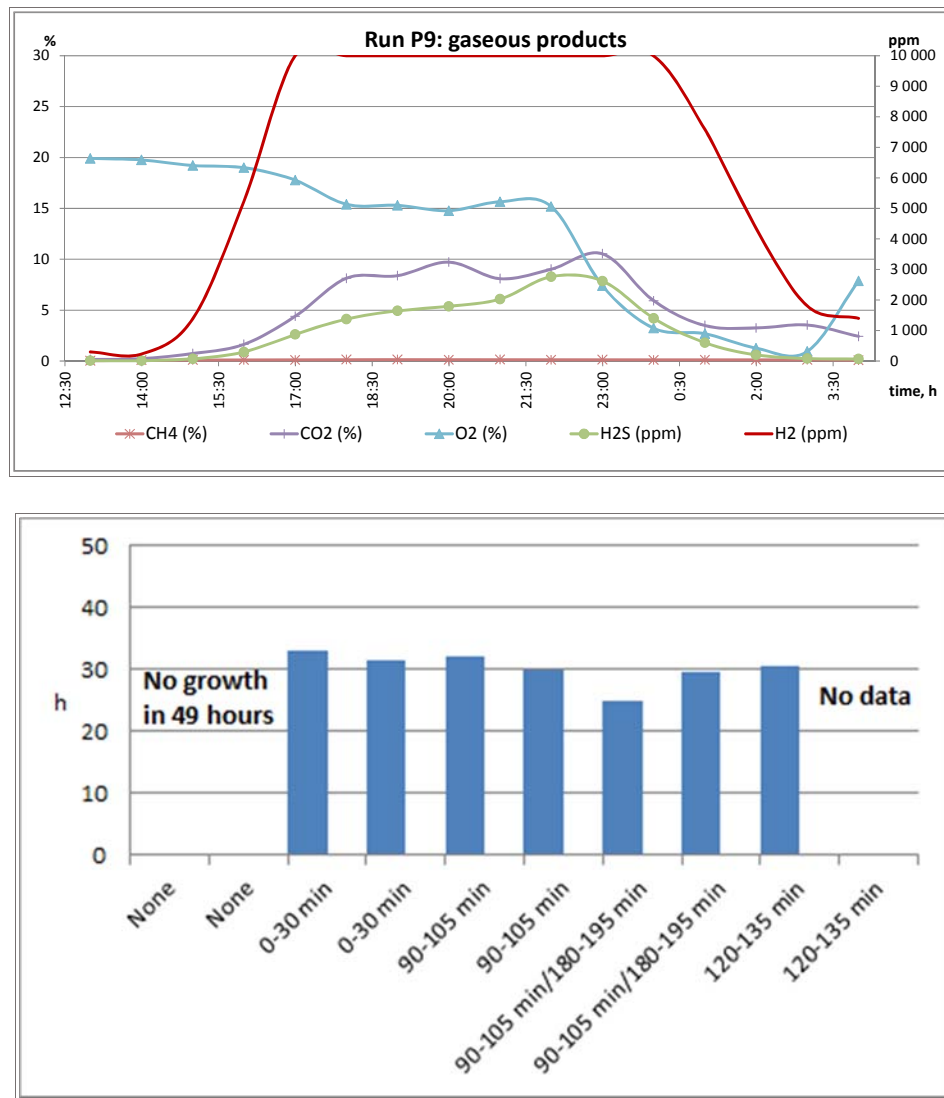


Figure 2. (a): Biohydrogen production from ABOWE Pilot A from potato industry waste mixed with sorted restaurant biowastes. Graph by Prof. Emilia den Boer, Wroclaw University of Technology, Poland. Hydrogen in red and oxygen in turquoise color. (b): Shortening of the onset of *Clostridium acetobutylicum* strain ATCC 185 growth by carbon dioxide in the PMEUSpectrion® cultures (Hakalehto 2015). Then a constant nitrogen (100%) flow was in some cases interrupted with pulses of 45% CO<sub>2</sub> with 15-30 min duration near the beginning of the cultivation. The triggering CO<sub>2</sub> impulses produced bacterial growth.

Carbon dioxide has been used in our experiments to boost up microbial growth. It shortened remarkably the onset of bacterial growth in pure *Clostridium butyricum* cultures when the outgoing gas from the PMEUSpectrion cultivation syringe was directed into the next syringe as sterile filtered<sup>3</sup>. This effect was also demonstrated with *Clostridium acetobutylicum*, *Escherichia coli* and *Klebsiella mobilis* (Hakalehto 2011; Hakalehto 2015). The shortening of the so called lag period after various CO<sub>2</sub> is illustrated in Fig. 2b. In fact, bacterial cultures have also a potential to assimilate it, and in

mixed cultures the carbon dioxide from lactobacilli boosted up clostridial growth. This could be used for biotechnical purposes, and also for preventing harmful emissions in climatological sense as the exhaust gases even from combustion processes can also be reused biotechnologically. Also nitrogen emissions can be studied by this method.

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## **Studies on Aerobic and Anaerobic Bacteria in Sediment and Their Importance in Water Quality Assessment**

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The expansion of human population and the resultant anthropogenic activities have led to the continued deterioration of our environment. This has revealed the importance of environmental indicators, such as microbial indicators, that help to detect the early changes in water quality and therefore the health of aquatic environments. This study sought to determine whether or not the ratios of viable aerobic and anaerobic bacteria cultured from sediment core samples could be utilized as bioindicators of water quality. Seven sampling sites located throughout the Lake Simcoe and Lake Couchiching watersheds in central Ontario were involved in the study. Temperature, conductivity, chlorophyll *a* concentration, pH, dissolved oxygen content, total suspended load, total phosphorus concentration, total nitrate concentration and total organic carbon were analyzed for their potentially relevant correlations with the existing bacterial communities in the sediment samples. Results indicated that there is a strong positive correlation between the dissolved oxygen content and the ratios of aerobic and anaerobic growth, total phosphorus concentration and the ratios of aerobic and anaerobic growth as well as pH and the ratios of aerobic and anaerobic growth. The information derived from this study concludes that aerobic and anaerobic bacterial distributions within sediment can indicate changes in water quality and therefore constructively contribute to water quality monitoring and assessments.

## Heavy Metal Contamination of Soils: Sources, Indicators, and Assessment

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Heavy metals are elements with metallic properties and an atomic mass of  $> 20$ . The most common contaminants of heavy metal are Cd, Cr, Hg, Pb, Cu, Zn, and As. Heavy metal contamination to soil and the environment has been accelerated in modern society due to industrialization, rapidly expanded world population, and intensified agriculture. Accumulation of heavy metals often results in soil/water degradation and ecosystem malfunction. Moreover, heavy metals enter food chains from polluted soil, water and air, and consequently cause food contamination, thus posing a threat to human and animal health.

Globally, more than 10 million sites of soil pollution have been reported, with  $>50\%$  of the sites are related to heavy metals and/or metalloids (such as arsenic) (Table 1). Heavy metal pollution has a combined worldwide economic impact estimated to be in excess of US \$10 billion per year.

Table 1. Soil pollution in the world (EEC, 2007; ADEC, 2010; EPMC, 2014; USEPA, 2014).

Country	Number of pollution sites	% of heavy metal(loid)s pollution
Global	$>10000000$	$>50$
USA	$>100000$	$>70$
European Union	$>80000$	37
Australia	$>50000$	$>60$
China	1.0 million km <sup>2</sup>	$>80$

Sources of heavy metal pollution include natural processes and anthropogenic activities. Soils may inherit heavy metals from parent materials such as those derived from metal-enriched rocks including serpentine and black shale (He et al. 2005). Anthropogenic sources of heavy metal pollution include mining, smelting, fossil fuel combustion, waste disposal, corrosion, and agricultural practices. For instance, irrigation with industrial waste water has resulted in heavy metal pollution to a large area of arable land and simultaneously led to contamination of millions ton of grain each year in China.



Many biogeochemical properties/parameters have been proposed and applied to indicate soil contamination with heavy metals. They include, but not limit to, chemical indicators (total/recoverable content, available/extractable amount, and fractionation), biochemical indicators (enzyme activity, FDA hydrolysis), microbial indicators (microbial biomass, microbial quotient, specific respiration, microbial metabolic quotient and microbial community structure), soil animal indicators (earthworm-quantity and variety) and plant indicators (biomass yield, uptake of metals and metal accumulation in edible parts). However, the most commonly used indicator for soil heavy metal pollution is still total/recoverable content, though extractable amount is more closely related to plant uptake or availability of heavy metal in soil and environment in many individual cases.

Heavy metal pollution is a global challenge, which requires joint efforts of government, scientists, and community alike. Governmental regulations are essential in both source control and pollution remediation. Regulatory standards for heavy metal levels for agricultural soils have been established (Table 2), but wide discrepancy exists among different countries regarding the critical value of each contaminant.

Table 2. Regulatory standards of heavy metals in agricultural soil (mg/kg) (US EPA, 2002; EEA, 2007; TMS, 2007; CME, 2009; EPAA, 2012; NZME, 2012; EPMC, 2015); pH and land use dependent; NZ=New Zealand.

Country	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Australia	20	3	50	100	1	60	300	200
Canada	20	3	250	150	0.8	100	200	500
China	20-40	0.3-0.6	150-300	50-200	0.3-1.0	40-60	80	200-300
Germany	50	5	500	200	5	200	1000	600
Tanzania	1	1	100	200	2	100	200	150
Netherlands	76	13	180	190	36	100	530	720
NZ	17	3	290	>10 <sup>4</sup>	200	N/A	160	N/A
UK	43	1.8	N/A	N/A	26	230	N/A	N/A
USA	0.11	0.48	11	270	1	72	200	1100

Assessment of soil pollution with heavy metals involves sampling of representative soils in a problematic area, analysis of metals and related properties (such as pH), and quantification of soil contamination/pollution against regulatory standards. The most commonly used methods of calculation and parameters include Hakanson potential ecological risk index (RI), geoaccumulation index (GI), enrichment factor (EF), Nemero comprehensive index (NCI), and pollution index (PI). Further research is needed to improve regulatory standards and assessment methods.

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## Colonial Waterbirds as Indicators of Environmental Change

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Aquatic birds are useful indicators of environmental change in both marine and freshwater environments (Elliott and Elliott 2013, Hebert et al. 1999). Fish-eating birds, such as gulls and terns, are top predators and integrate ecological processes occurring throughout the food web. Because they occupy high trophic levels these species also accumulate high levels of biomagnifying contaminants such as mercury and polybrominated diphenyl ethers. These aspects contribute to the utility of these species as environmental indicators; hence, colonial waterbirds are the focus of various monitoring programs located across Canada (Fig. 1). Eggs constitute the majority of samples collected as part of this work. Colonial waterbird eggs are formed primarily from resources obtained in the vicinity of the breeding colony; therefore, the chemical composition of eggs will reflect the local environment.



Figure 1. Location of waterbird egg collection sites.

Much of Environment Canada's research on waterbirds has focused on the assessment of spatial and temporal trends in contaminant levels (Hebert et al. 2013), detection of emerging contaminants (Gebbink et al. 2011), and identification of ecosystem change through modification of food web structure (Hebert et al. 2008). Large-scale aquatic ecosystem change is often associated with alterations in the structure of biological communities. This in turn, affects how much and by what pathways energy, nutrients, contaminants, and disease agents flow through food

webs. Top predators track changes in resource availability through their selection of prey and, in so doing, integrate food web processes over time. Temporal changes in food web interactions can thus be characterized through retrospective measurement of biochemical indicators of organism trophic position and energy/nutrient flow in archived tissue samples of high trophic level predators (Hebert et al. 2008).

The National Wildlife Specimen Bank (NWSB) in Ottawa is the largest repository of frozen wildlife tissues in Canada. The NWSB is an important source of specimens for retrospective “ecological tracer” analysis. Examples of such ecological tracers are nitrogen and carbon stable isotopes and fatty acids. Stable nitrogen isotopes are useful in defining an organism’s trophic position as the heavier isotope,  $^{15}\text{N}$ , is progressively enriched through the food web leading to greater  $^{15}\text{N}$  values in organisms occupying higher trophic positions. Carbon isotopes provide information regarding the flow of carbon to consumers in that they can be used to differentiate between aquatic and terrestrial food sources. Fatty acid profiles in archived tissues such as eggs can provide additional insights into wildlife diets. Thus, retrospective ecological tracer analysis provides an historical perspective on food web tropho-dynamics allowing an evaluation of the extent and significance of food web change over time.

This presentation will demonstrate how data from colonial waterbirds are being used to improve our understanding of contaminant dynamics and trends in the Canadian environment. We will also examine how endpoints measured in waterbirds are providing insights into large-scale ecosystem change that is being manifested as alterations in the availability of resources for high trophic level predators as well as changing disease dynamics, e.g. emergence of botulism type E as a major factor causing wildlife mortality in the Great Lakes. Integration of data generated from the study of colonial waterbirds can provide a more holistic perspective on how changes in individual monitoring species may be reflecting larger, ecosystem-scale change (Fig. 2).

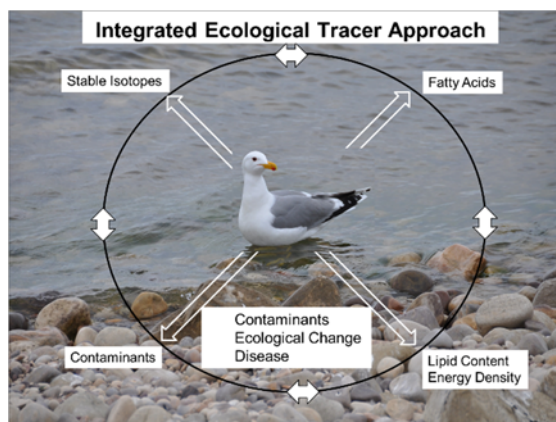


Figure 2. Integrated ecological tracer approach provides a holistic view of how alterations in endpoints measured in a biomonitoring species reflect larger ecosystem-scale change.

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## **Rice Husk Derived Engineered Biochar for Glyphosate Removal in Aqueous Media**

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The presence of glyphosate in waters at an elevated concentrations has received much attention worldwide in the recent decade, due to its ill consequences on the surrounding ecosystem as well as human beings (Bradberry et al. 2004). Hence, the remediation of glyphosate contaminated waters is an urgent necessity. Carbon-rich solid substrates such as biochars (BCs) have been recognized as an alternative and economically viable strategy to remove various inorganic and organic contaminants present in wastewaters. The activation of BC surface via steam activation is capable of enhancing the adsorption capacity of the BC (Rajapaksha et al. 2014). The main objective of the present study was to investigate the potential of a steam activated BC derived from rice husk to remove glyphosate from aqueous solution. The BC was produced from rice husk under slow pyrolysis conditions at 700 °C with steam activation in a furnace. Batch adsorption and isotherm experiments were carried out to evaluate the effects of pH, reaction time and glyphosate loading on the adsorption process. Three kinetics models including the Pseudo-first order, Pseudo-second order and Elovich were applied to evaluate the behavior of adsorption kinetics, whereas the Langmuir and Freundlich isotherm models were applied to determine the equilibrium parameters on the adsorption capacity of the BC. Results showed that a maximum sorption of glyphosate (82.0%) occurs at pH 4 and the adsorption capacity is decreased significantly with increasing pH. The Freundlich model fitted best the equilibrium isotherm data suggesting a physisorption that triggers via a multilayer sorption mechanism on heterogeneous and amorphous surfaces of BC. The kinetics of the adsorption process were described by the Pseudo-first order model with an adsorption capacity of 31.6 mg/g indicating that the adsorption of glyphosate onto the BC would be more inclined towards physisorption mechanisms depending on the initial concentration of glyphosate. Porous diffusion and  $\pi$ - $\pi$  electron donor-acceptor interaction were the main mechanisms responsible for the adsorption process. Overall results demonstrated that this steam activated rice husk BC is highly effective in removing glyphosate in aqueous solution.

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## Using Ecological Indicators to Assess Ecosystem Health in Tropical Reservoirs in Brazil

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With the purpose of developing an effective means of assessing the ecosystem health of tropical reservoirs we are developing and validating the Planktonic Index of Biotic Integrity (P-IBI) proposed by Kane et al., 2009 for tropical reservoirs. These systems represent an intermediate environment between lakes and rivers, and this heterogeneity must be taken into account for the practical purpose of management. To date, we have sampled the phytoplankton and zooplankton communities and determined the reservoirs' trophic condition.

The Paranapanema River is one of the main tributaries of the Paraná River (La Plata basin), located between the coordinates 22°-26° S and 47°-54° W. The river is the natural border between the states of Paraná and São Paulo (Fig. 1), with an extension of 929 km. Over the last four decades, eleven hydropower plants were constructed in the main course of the river. Three of the reservoirs are accumulation systems (i.e. high water retention times), whereas the others are run-of-the-river dams.

For this study the three reservoirs of accumulation (Jurumirim, Chavantes, and Capivara) were selected, as they are more lake like. Field sampling of physical, chemical and biological (phytoplankton and zooplankton) parameters was conducted in two sampling campaigns carried out in March and October of 2011, trying to incorporate the main influences of seasonal variations (wet and dry season). For each reservoir we considered six sampling stations including the main spatial compartments identified from previous studies, which are arranged in a gradient established between the lotic (Paranapanema River entrance) and lentic (dam) areas.

According to the trophic state index for tropical/subtropical reservoirs (TSI<sub>tr</sub>) proposed by Cunha et al. (2013), the sample stations are categorized as ultraoligotrophic to mesotrophic, featuring low concentrations of phosphorus and chlorophyll *a*. They have heterogeneous morphometry and are very dendritic (Table 1, Fig. 1). Ongoing studies are being carried out by researchers at the State University of São Paulo, Campus of Botucatu, as part of a Limnological and Water Quality monitoring program of the Paranapanema River reservoir cascade, now the responsibility of Duke Energy Generation Paranapanema.

The development and application of a viable Planktonic Index of Biotic Integrity (P-IBI) will be of use for management of these large reservoir systems. Further, it will compliment various research lines already present in the Laboratory of Ecology of Continental Water (IBB-UNESP), extending and broadening the group's scope.

Table 1. Characteristics of study reservoirs.



	Jurumirim	Chavantes	Capivara
Area (km <sup>2</sup> )	449	400	576
Volume (hm <sup>3</sup> )	7.2	9.4	10.54
Retention time (days)	323	418	150
Z <sub>max</sub> (m)	32	79	40
Altitude of water level (m) (a.s.l)	563	473	325
TSI <sub>trs</sub>	Ultra - Oligotrophic	Ultraoligotrophic	Ultra - Mesotrophic
TSI <sub>trs</sub> range	46.56 – 52.38	47.22 – 50.33	49.40 – 55.65

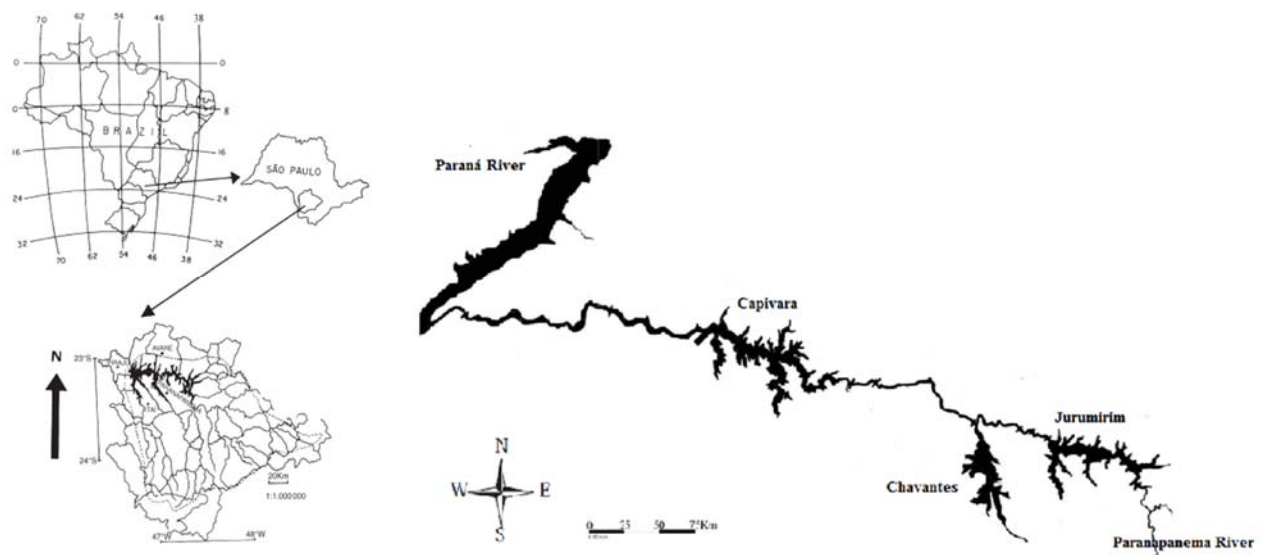


Figure 1. Location of Paranapanema River and the selected reservoirs.

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## **Soil Carbon Pool as an Environmental Indicator**

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Soil (pedosphere) is an important component of the environment, and it interacts closely with atmosphere, hydrosphere and the biosphere. As the largest reservoir of carbon (C) in the terrestrial ecosystems, it is a major determinant of atmospheric chemistry, climate change, and an important component of the global C cycle. In turn, climate is an active factor of soil formation. Similarly, soil properties and processes also impact the hydrological cycle. Soil and its effective rooting depth is the source of “green water” or the plant available water (PAW) reserve. There exists a close relationship between soil organic C (SOC) content and PAW capacity. Water quality is also affected by SOC concentration through its impact on soil erodibility, sediment transport, and non-point source pollution. Concentration, quality, and dynamics of SOC are strong controls of the activity and species diversity of soil biota, especially that of the microbial biomass C. Macrofauna (e.g., earthworms, termites) are also affected by the amount of SOC pool, its size fractions, and the mean residence time (MRT). Soil quality, ecosystem goods and services provisioned under a specific landuse, is also affected by SOC concentration, its depth distribution, and physical/chemical properties. The threshold or critical level of SOC concentration in the root zone is 15 to 20 g/kg, and soil quality declines rapidly with a strong decline in SOC concentration. The aboveground biomass and rate of plant growth (the net primary productivity or NPP) are also affected by SOC concentration. Agronomic productivity and use the efficiency of inputs depend on SOC concentration and the attendant impact on soil quality. There exists a strong link between soil health, plant health, animal health, and human health. Indeed, the soil-plant-animal-environment is a continuum, and indivisible. The SOC pool is an elixir of life, and is one of the most precious resources. Severe decline in SOC pool adversely impacts the environment, nature conservancy and human wellbeing.

## **Simple or Better: Comparing Two Methods for Mapping Soil Conservation Service of Terrestrial Ecosystems**

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Spatially explicit mapping of ecosystem services (ESs) is one of the critical manners for mainstreaming ESs into decision-making that deal with land use and ecological conservation planning. Soil conservation service (SC), an important regulating service of terrestrial ecosystems, draws great concerns of stakeholders and decision-makers during the policy making process. Contemporarily, the Revised Universal Soil Loss Equation (RUSLE) based empirical soil erosion models are the staple methods used to quantitatively assess the SC of ecosystems. In this paper, we present a newly formulated composite indicator based method for mapping the SC which can be used at regional or larger spatial scales. After comparing the spatial patterns and temporal variations of SC from the RUSLE based model and those from the indicator based method in Jiangxi province of China, the similarities and differences of these methods were revealed. Findings suggest that the biophysical indicator method can effectively ranking terrestrial ecosystems on their capability to provide SC service at large spatial scale. The mapping results are conform to both the findings based on field observations at various environmental settings and the general implementation of soil conservation practices. Therefore, the biophysical indicator method is suitable for large scale SC mapping with targets of soil conservation planning and conservation effectiveness evaluation even it is much simpler than the traditional empirical models such as RUSLE. RUSLE is similar to the biophysical indicator method in reflecting different ecosystem (or land cover) types on their ranking of SC capability. But it is problematic in the results on spatial pattern of SC for lack of support from the published literature on the soil conservation monitoring and practical applications. This problem may be largely rooted in its very extreme and unrealistic assumption when RUSLE is borrowed to map SC of ecosystems. In fact, RUSLE has been used and verified globally in soil loss assessment and its environmental risks. But this does not necessarily guarantee its usability as a sound SC mapping tool. On the contrary, the findings of the present research strongly recommend great caution for the use of RUSLE to map the SC service of ecosystems as shown in this paper and the published literature especially to the spatial pattern of SC and its temporal change. Therefore, the newly formulated simple biophysical based composite indicator method is by no means worse in mapping the rankings and spatiotemporal variations of SC in terrestrial environment, this research revealed its advantages for SC mapping for the purpose of soil conservation planning and conservation performance assessment especially at large spatial scales.

## **Challenges in Environmental Governance: A Case Study of Risk Perceptions of Environmental Agencies Involved in Flood Management in the Hawkesbury-Nepean Region, Australia**

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The management of environmental resources require engagement of a range of stakeholders including public/private agencies and different community groups to implement sustainable conservation practices. The challenge which is often ignored is the analysis of agencies involved and their power relations (Ford 2003). One of the barriers identified is the difference in risk perceptions among the agencies involved that leads to dis-jointed efforts of assessing and managing risks. Wood et al. 2012, explains that it is important to have an integrated approach to risk management where decision makers address stakeholder perspectives. This is critical for an effective risk management policy. According to Wood et al. (2012), in most cases, human dimensions to disaster management are identified but the process of 'how to' integrate interests, knowledge and values of stakeholders' remains underdeveloped.

The Australian climate is characterised by extreme weather conditions. Future unpredictability has placed pressure on government agencies to increase their effectiveness of managing adaptation to extreme weather events, increase coordination and improve risk assessment and its communication. The Australian Emergency Management Floodplain Management Framework signifies the need for a cooperative approach to managing flood risks; different tiers of governance need to work together and provide technical, financial, legislative and regulatory inputs to manage risks (COAG 2011). However, Berke (1989) identifies barriers to coordination between different tiers of governance and across jurisdictions. Lustiq and Maher (1997) also point out that the complex arrangement of agencies managing flood risks has led to poor coordination and management in Australia. It presents the complex nature of a multi-tier governance system that creates ambiguity in having multiple risk analysts, management of risks and sharing of risk-based information among a wide range of stakeholders.

This paper will look into barriers to flood management under a changing climate and intends to identify bottlenecks that create maladaptation. Experiences are drawn from international practices in the UK and examined in the context of Australia through exploring the flood governance in a highly flood prone region in Australia: the Hawkesbury Nepean catchment as a case study.

The Hawkesbury-Nepean Catchment covers an area of 22,000 km<sup>2</sup>. It is one of the major river systems in New South Wales, Australia (Gillespie et al. 2002). Its unique geographical characteristics increase its susceptibility to significant flood risks. The problem is further exacerbated due to the development in the floodplains with an increase in population in the coming decades. New development plans indicate that approximately 180,000 dwellings are planned in the catchment with an investment of 7.5 billion in infrastructure (Smart Consulting 2013). The estimated economic loss of 1.5-2.5 billion under a 100 year Average Recurrence Interval flood is

estimated (Ribbons 1997). A flood event of 2010-2011 in Queensland could impact the entire NSW economy by impacting transport routes facilities (Office of Water 2014).

In this research study several aspects of governance and management are explored: (1) the complexities created by the way different agencies are involved in assessing flood risks (2) different perceptions on acceptable flood risk level; (3) perceptions on community engagement in defining acceptable flood risk level; (4) Views on a holistic flood risk management approach; and, (5) challenges of centralised information system.

The study concludes that the complexity of managing a large catchment is exacerbated by the difference in the way professionals perceive the problem. This has led to: (1) different standards for acceptable risks; (2) inconsistent attempt to set-up a regional scale flood management plan beyond the jurisdictional boundaries; (3) absence of a regional scale agency with license to share and update information (4) Lack of forums for dialogue with insurance companies to ensure an integrated approach to flood management. The research takes the Hawkesbury-Nepean catchment as case example and draws from literary evidence from around the world. In addition, conclusions were extrapolated from eighteen semi-structured interviews from agencies involved in flood risk management in the Hawkesbury-Nepean catchment of NSW, Australia. The outcome of this research is to provide a better understanding of complexity in assessing risks against a rapidly changing climate and contribute towards developing effective risk communication strategies thus enabling better management of floods and achieving increased level of support from insurance companies, real-estate agencies, state and regional risk managers and the effected communities.

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## **Kinetic and Thermodynamic Studies on Adsorption of Copper (II) Ions onto the Olive Pomace Lignocellulosic in the Region of Beni Mellal (Morocco)**

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Despite the recent developments in the field of wastewater treatment, and despite the new modern technologies that have emerged in this domain, adsorption is still a reliable procedure for the removal of toxic substances such as heavy metals from wastewater. The aim of the present work is the valorization of lignocellulosic material prepared from olive pomace in the field of pollutant treatment of various liquid effluents containing heavy metals toxins such as copper. The chemical characterization of the surface was carried out by the pH at the point of zero charge; this indicates the acidic character of the materials. The satisfactory operating conditions were performed at pH 4, a particle size below 80  $\mu\text{m}$  and a temperature of 20°C. The characterization of solids obtained before and after extraction of the hemicellulose of the olive pomace was performed by IR and SME. The results showed that the extraction of hemicellulose has a great influence on the structural, textural and morphological properties as well as the cation exchange capacity (CEC) of olive pomace. The kinetic study (pseudo-first order and pseudo-second-order), thermodynamic and mechanistic (isotherms Langmuir, Freundlich, Temkin, and Dubinin Radushkevich) of the adsorption of Cu(II) ions on the lignocellulosic obtained from the olive pomace was conducted in aqueous solution. The results were permeated us to specify in a static reactor: the adsorption kinetics and the thermodynamic parameters of adsorption of copper ions.

# **Synergy Potential among Climate Change Mitigation, Adaptation, and Biodiversity and Ecosystem Conservation in the Forest Sector**

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Governance for climate change mitigation and adaptation measures, as well as for biodiversity and ecosystem conservation measures, is discussed under different conventions: mitigation and adaptation under the United Nations Framework Convention on Climate Change (UNFCCC) and biodiversity and ecosystem conservation under the Convention on Biological Diversity (CBD). However, currently there are growing interests in integrating these climate change measures and biodiversity/ecosystem conservation measures, with a view to increasing their benefits and reducing their negative impacts. Existing research shows the co-benefits of some fields by integrating mitigation and adaptation measures within the field of climate change, and it also explores the co-benefits by integrating mitigation and biodiversity/ecosystem conservation, as well as adaptation and biodiversity/ecosystem conservation. However, there is limited research on the synergy among mitigation, adaptation, and biodiversity/ecosystem conservation.

This research explores synergy potential among climate change mitigation, adaptation, and biodiversity/ecosystem conservation in the forest sector by using the indicators developed based on the existing enabling conditions on synergy between climate change mitigation and adaptation (Duguma et al. 2014). We use the case of the forest sector because it is likely to have high synergy potential among mitigation, adaptation, and biodiversity/ecosystem conservation. All mitigation, adaptation, and biodiversity/ecosystem conservation in the forest sector require forest conservation activities.

In order to evaluate the national synergy potential among the three measures mentioned above, we apply indicators proposed by Duguma et al. (2014). Since they focus only on climate, we have added biodiversity/ecosystem conservation to their indicators and focus on the forest sector. The study will examine the following questions (indicators).

1. Policies and strategies
  - 1.1 Does the country have a policy that addresses mitigation (M), adaptation (A), and biodiversity/ecosystem conservation (BE) in the forest sector?
  - 1.2 Is there a common strategy/action plan for M, A, and BE in the forest sector?
  - 1.3 Has the country submitted Nationally Appropriate Mitigation Actions (NAMA)/Reducing Emissions from Deforestation and Forest Degradation in Developing Countries etc. (REDD+), Readiness Preparation Proposal (R-PP), National Adaptation Programmes of Action (NAPA) to the UNFCCC, and National Biodiversity Strategies and Action Plans (NBSAP) to the CBD?
2. Institutional arrangements
  - 2.1 Is there a national-level committee addressing M, A, and BE in the forest sector?



- 2.2 Is there an implementing body (e.g., institution, agency, department, and/or unit) addressing M, A, and BE in the forest sector?
3. Financing
  - 3.1 Is there a common fund for M, A, and BE in the forest sector?
4. Programs and projects
  - 4.1 Is there a joint program addressing M, A, and BE in the forest sector?
  - 4.2 Are there subnational projects addressing M, A, and BE in the forest sector?

We applied the indicators above to the countries in the Asian region, where the forest is a key sector when considering climate and biodiversity/ecosystem conservation issues. It is common among Asian countries for few laws to address M, A, and BE in the forest sector simultaneously, while their existing strategies, programs, and projects address M and BE or A and BE. Further, in addressing M, A, and BE in the forest sector, since the ministry that addresses environmental problems and the ministry that addresses forest-related problems have different purposes and roles, even though both ministries' works are related to the M, A and BE in the forest sector, more cooperation between the ministries is necessary.

The following study of Cambodia is an example of our case studies. The answers to the questions are “yes,” “partially,” or “no.”

- 1-1: No (no law addresses all M, A, and BE, and neither M and BE nor A and BE)
- 1-2: Yes (e.g., Cambodia Climate Change Strategic Plan 2014–2023 and National Forest Programme 2010–2030)
- 1-3: Partially (no NAMA is registered)
- 2-1: Partially (e.g., National Climate Change Committee addresses M and A, and REDD+ Taskforce addresses M and BE)
- 2-2: Partially (e.g., Ministry of the Environment addresses M, A, and BE; however, M in the forest sector is mainly addressed by Forestry Administration)
- 3-1: Partially (e.g., Cambodia Climate Change Alliance Trust Fund focuses on A and also addresses BE)
- 4-1: Partially (e.g., UN-REDD program in Cambodia addresses M and BE)
- 4-2: Partially (e.g., Wildlife Conservation Society Seima Project addresses M and BE)

Our preliminary results suggest that although the forest sector has great potential to generate synergy among mitigation, adaptation, and biodiversity/ecosystem conservation, there are institutional challenges to enhancing their synergies. For example, the lack of holistic policies that address all three measures in the forest sector. Further, it is likely that the synergy between mitigation and biodiversity/ecosystem conservation, as well as between adaptation and biodiversity/ecosystem conservation, is able to be promoted through the existing programs and projects, such as REDD+ and ecosystem-based adaptation, while synergy between mitigation and adaptation requires more institutional changes.

Future analytical tasks include exploring environmental indicators that evaluate the actual environmental benefits of synergies among the three measures; assigning weights to each indicator so that we can compare each country's synergy potential easily; and determining whether indicators are applicable to sectors other than the forest sector.

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## Characterization And Phytoremediation Of Crude Oil Contaminated Wetland

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Levels of metal and hydrocarbon contaminants were determined in water from a wetland around an abandoned oil-well in Mgbuoba Community in the Nigerian Niger Delta. The performance of *Hevea brasiliensis* at clean – up of resulting effluent was also investigated. *H. Brasilensis* was grown hydroponically in the effluent for 43 days in the presence of white light and a salted variant while growth indices were measured. Deionized water was used as control and all experiment was done in triplicates. Levels of Phenol and some heavy metals were determined at 0d and 43d to ascertain performance. Observed levels of Fe, Pb, Cd, Phenol and total hydrocarbons were statistically significant at  $p \leq 0.05$  and reduced by 99.8%, 99.9%, 99%, 99.9% and 80.01% respectively. Cyanide, mercury and chromium were not detected for all samples. Salted regimes showed markedly higher uptake of heavy metals. Also, produced biomass compared favourably with control, and is indicative of remarkable tolerance to induced phytotoxicity. Generally results indicate excellent phytoextraction of studied contaminants, leaving relatively low values in the effluent, and thus present *H. brassiliensis* as a candidate for the phytoremediation of crude oil contaminated soil.

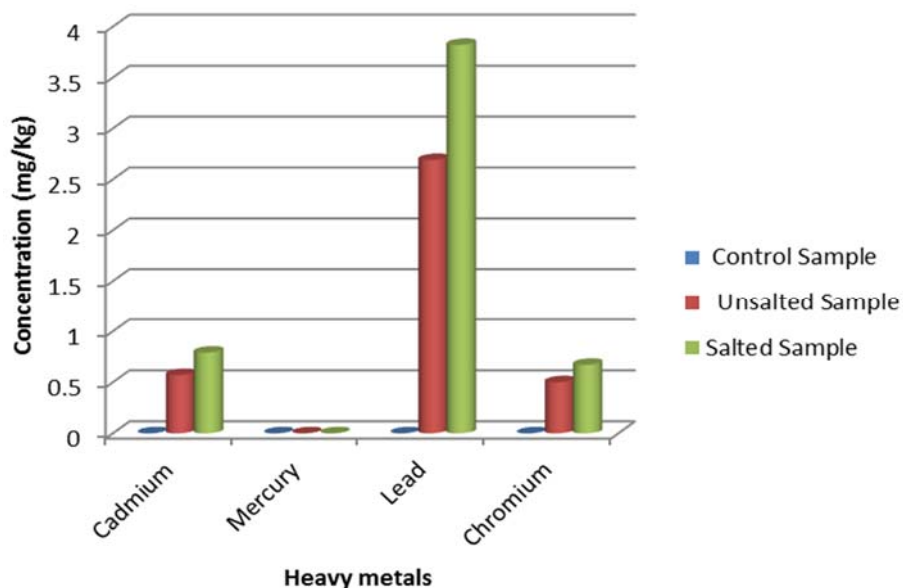


Figure 1. Some heavy metals uptake levels by plants (shoots) in the control (deionized water as growth medium), unsalted and salted contaminated samples.

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## ***In Vivo* Mutagenic and Oxidative Stress Modulatory Effects of Fenthion in Freshwater African Catfish *Clarias Gariepinus* (Burchell 1822)**

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The present study was designed to evaluate the mutagenic and oxidative stress effects of fenthion on the tissues of African catfish *Clarias gariepinus*. Fish specimens were exposed to three (2.0, 4.0, 8.0 mg/L) sublethal concentrations of fenthion and a control. The blood erythrocytes of the exposed specimen were sampled on day 1, 7, 14, 21 and during 7 days recovery to assess the DNA damage using micronucleus test. The gill and liver tissues were also sampled during the same period to assess the alterations in lipid peroxidation and antioxidant enzyme activities. Micronuclei induction in blood erythrocytes was highest (7.55) on day 14 of exposure but gradually declined during the 7 days recovery. There was dose and time dependent induction of oxidative stress as evidenced by increased lipid peroxidation level. Other antioxidants such as reduced glutathione (GSH), glutathione reductase (GR), glutathione peroxidase (GPx), superoxide dismutase (SOD) and catalase responded differently in the tissues during the exposure and recovery periods. Fenthion should be used with caution as sublethal exposure elicited induction of micronucleus, lipid peroxidation and alterations of other antioxidant enzyme activities.

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## **Governance of Oil/Gas Sector in Nigeria: Impacts on Water Resources in the Niger-Delta Region**

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Given the persistence of environmental problems that characterise the oil producing communities (OPC) of Nigeria, often referred to as the Niger Delta region (NDR), this study examines the impacts of the governance of oil and gas sector on the water resources in the region. The NDR is a coastal area that is most endowed in terms of natural resources including water, oil and gas among others. Paradoxically, despite the availability of fresh water resource, the region has been struggling with acute potable water shortage since 1980s. However, the continued exploration and production of oil and gas is having deleterious impacts on water resources which transcends government and oil and gas companies' efforts to address. This state of affairs which has been an issue of great concern nationally, calling therefore for the examination of the governance of the oil and gas sector with regards to water problem/contamination in the region.

Informed by review of academic literature, this study advanced an interactive governance framework (IGF) that promotes recognition and involvement of the various relevant actors/stakeholders, including the locals in the OPC. The study was conducted in two OPC in Nigeria and primary data was collected through a total of 4 focus group discussions, 1 workshop and 25 in-depth interviews, including at least one representative each from 20 government agencies, one representative each from 3 environmental NGOs, one representative each from both a Community-based Organisation and Hybrid organisation.

Analysis of the data shown that the governance of oil and gas sector has contributed to water resources contamination, which has ultimately exacerbated the conditions of living of the coastal communities. The empirical evidence equally suggests that water resources contamination persists, because the locals in the OPC whose values, norms and principles are supposed to be considered in policies and decision-making are not fully involved in the governance process and the governing actors also lack the requisite capacity to perform. The study concluded that IGF is a good antidote to address the governance challenges as well as the various environmental problems including the water resources contamination that characterised the oil and gas sector in Nigeria.

## Growth Pattern, Size Composition and Condition Factor of Five Fish Species of Sciaenidae Trawled from Nigerian Coastal Water

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The growth pattern and condition factor for five species of family *Sciaenidae* trawled from Nigeria coastal water were investigated in 2009. A total of 1,945 specimens ranging from 2.0-62.0 cm in total length and 1.70 - 1500.00g in weight were analyzed. Total length and weight were measured using standard methods. The degree of association between length and weight was computed from linear regression analysis, for growth pattern relationship is shown by the following equation:  $\text{LogW} = -1.6058 + 2.5958 \text{ LogL}$  (*P. senegalensis*),  $\text{LogW} = -2.6019 + 3.4585 \text{ LogL}$  *Pseudotolithus epipercus*,  $\text{LogW} = -1.6350 + 2.7367 \text{ LogL}$  *Pentheroscion mbizi*,  $\text{LogW} = -1.3947 + 2.5554 \text{ LogL}$  *Pteriscion peli*,  $\text{LogW} = -1.9891 + 2.8601 \text{ LogL}$  *Pseudotolithus typus*. All species studied exhibited positive allometric growth ( $b > 3$ ) except *Pseudotolithus epipercus* with  $b = 3$ , 45 that exhibited positive allometric equation with the mean  $b = 2.84$  at  $p < 0.001$ . The  $r^2$  values ranged from 0.7876 for *P. senegalensis* to 0.9452 for *P. epipercus*, and all regression were highly significant ( $p < 0.001$ ). The condition factor ( $k$ ) ranged from  $0.69 + 0.27$  (*P. typus*) to  $2.34 + 32.28$  (*P. senegalensis*) while relative condition factor ( $K_n$ ) ranged from  $1.63 + 2.40$  (*P. peli*) to  $3.72 + 8.67$  (*P. typus*). Relative condition ( $K_n$ ) revealed that *P. typus* was more robust and in a better state of wellbeing rather than *P. senegalensis* with highest mean condition factor ( $K$ ). The best condition factor was recorded for those individual within the lowest size groups. All the species studied are in good condition ( $k \leq 0.5$ ).



## Biochemical Indicators of Contaminate Exposure in Mangrove Periwinkle, *Tympanotonous Fuscatus* in Tidal Polluted Creeks in Lagos Metropolis

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Cellular oxidative stress biomarker response [lipid peroxidation using thiobarbituric acid reactive substances (TBARS), superoxide dismutase (SOD), glutathione (GSH) and catalase-enzymes (CAT)] activities in periwinkle, *Tympanotonous fuscatus* were evaluated in tidal polluted creeks in Lagos metropolis. *T. fuscatus* were collected from three aquatic environments namely; Agboyi Creek (AAC), Lagos Lagoon (BLL) and Lekki Lagoon (CLL) in Lagos metropolis where activities of pollutants and xenobiotic compounds may be high. Enzymatic activities were expressed in relation to protein concentration which was determined as outlined by Radox (Total protein [Biuret method]). No significance difference ( $p > 0.05$ ) were observed for either TBARS or GSH activities for all the three sites (AAC, BLL and CLL). However, SOD and CAT activities were significantly different ( $p < 0.05$ ). The mean concentrations of TBARS, GSH, SOD and CAT in *T. fuscatus* were low in site AAC with the following values; 338.64  $\mu\text{mol}/\text{min}/\text{mg}$  protein, 264.48  $\text{mmol}/\text{min}/\text{mg}$  protein, 53.41  $\mu\text{mol}/\text{min}/\text{mg}$  proteins, and 205.75  $\text{mmol}/\text{min}/\text{mg}$  protein respectively. The mean concentration of GSH and SOD were highest with the following values 280.61  $\text{mmol}/\text{min}/\text{mg}$  protein and 178.22  $\mu\text{mol}/\text{min}/\text{mg}$  proteins respectively at site BLL. Also the concentration of TBARS and CAT were highest at site CLL with the following values 856.94  $\text{mmol}/\text{min}/\text{mg}$  protein and 467.45  $\mu\text{mol}/\text{min}/\text{mg}$  proteins respectively. Analysis using student Newman Keuls at ( $p = 0.05$ ) showed that the concentration of TBARS and GSH in *T. fuscatus* were not significantly different in all the sites. However, SOD and CAT showed significant different in sites BLL and (AAC and CLL) respectively. Considering that many of the pollutants are capable of absorption by aquatic organisms which usually induce oxidative stress due to the production of oxyradicals during detoxification processes, it is possible that site AAC (Agoyi creek ) with reduced antioxidant enzymes activities would be more susceptible to the effects of xenobiotic compounds.

## Microbial Accumulation and Transformation of Nanoscale Elemental Selenium Particles

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### INTRODUCTION

Nanomaterials have unique physiochemical and biological properties that are primarily based on quantum effects of small particle size and larger surface area, which provide great driving forces for diffusion and increase reactivity in the environment. Due to the rapid development of nanotechnology in recent years, more Se nanoparticles (SeNPs) have been applied in various medical, nutritional, industrial, and remediation processes (Huang et al. 2015; Wang et al. 2015). Because SeNPs are one of several contaminants of emerging concern, their environmental impacts could be significantly different from bulk elemental Se and other Se compounds. Thus, the transport and fate of Se in the environment can be significantly affected by the presence of nanoscale elemental Se particles.

Soil microorganisms play an important role in determining the ecotoxicity of Se in the environment. Although previous studies have demonstrated the toxicity of SeNPs to different microbes (Li et al. 2008), little is known about microbial accumulation and transformation of chemically synthesized SeNPs in the environment. Thus, it was hypothesized that, compared with bulk elemental Se, SeNPs Se might be bioavailable for bacterial accumulation and transformation. The specific objective of this study was to (1) determine the bioaccumulation of SeNPs in a plant-associated soil bacterium, and (2) determine the extent of biotransformation of SeNPs by the presence of a soil microbe.

### MATERIALS AND METHODS

**Synthesis of selenium nanoparticles:** The chemical synthesis of SeNPs was conducted using a mixed surfactant template method (Li and Hua 2009). In brief, selenious acid ( $\text{H}_2\text{SeO}_3$ ) was reduced by ascorbic acid ( $\text{C}_6\text{H}_8\text{O}_6$ ) to form nanoscale elemental Se particles that were coated with surfactant, a mixture of sodium dodecyl sulfate and polyvinyl alcohol. Nanosight LM 10 and Malvern ZetaSizer Nano were used to characterize SeNPs in the solution. The bacterial strain for this study was *Pseudomonas sp.* that was previously isolated from the rhizosphere soil of *Stanleya pinnata*. To determine the effect of SeNPs (~75 nm) on the bacterial growth, the optical density at 600 nm ( $\text{OD}_{600}$ ) of a bacterial cultural solution (LB broth) that was treated with different levels of SeNPs was measured to establish a bacterial growth curve. The cultural solutions were centrifuged and bacterial pellets were washed and collected.

Concentrations of Se were analysed using ICP-MS. In addition, the cultural solutions were also treated with  $\text{Na}_2\text{SeO}_4$ ,  $\text{Na}_2\text{SeO}_3$ , elemental SeNPs, or  $\text{C}_5\text{H}_{11}\text{NO}_2\text{Se}$  (SeMet) at 5  $\mu\text{g/ml}$ . Each treatment had three replicates. Selenium speciation analysis of SeNP-treated bacterial solution was

conducted using HPLC-ICP/MS, including Se standards of selenate, selenite, SeNPs, SeMet, selenocysteine (SeCys), and Se-methylselenocysteine.

## RESULTS AND DISCUSSION

Compared with the control, the SeNP treatments of 10 and 25 mg/L significantly ( $p > 0.05$ ) reduced the growth of the bacterial strain during an 8-hour experimental time period, while the SeNP treatment of 1 and 5 mg/L significantly enhanced the bacterial growth. *Stanleya pinnata* is a Se hyperaccumulator species, and *Pseudomonas sp.* has relatively high tolerance to Se in the growth substrate. Thus, high SeNP concentrations of  $>5$  mg/L might result in impairments on soil microbial community. The concentration of SeNP in the bacterial pellets increased with increasing the concentration of SeNPs in the growth substrate. The highest Se concentration was observed from the treatment of 10 mg/L, which might result in lower bacterial growth.

The effects of different Se chemical forms (selenate, selenite, bulk elemental Se, SeNPs, and SeMet) in the cultural solution were evaluated at the treatment level of 5 mg/L. The SeNP treatment showed the highest Se concentration in bacterial cells, followed by bulk elemental Se. Compared to SeNPs, the selenate, selenite, or SeMet treatment showed considerably lower Se concentrations in bacterial cells. Although bacterial cell pellets were washed twice using fresh cultural solution (LB broth), high Se concentrations in bacterial cells from the SeNP and bulk elemental Se treatments were likely due to elemental Se deposition on cell surfaces. The speciation analysis showed that the dominant chemical forms of Se in the supernatant of the SeNP-treated bacterial solution included SeCys and one unidentified Se compound, but no SeNPs observed.

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## Indicating Impacts of Climate Change and Nitrogen Deposition on Ecological Integrity of Forests

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Under action 5 of the EU Biodiversity Strategy to 2020, the condition of ecosystems and their services should be mapped and assessed across Europe. As a contribution to reach this aim, a method for evaluating and mapping historical, current and potential future ecological integrity of forests was developed using examples from Germany. The methodology integrated data on vegetation, chemical and physical soil conditions as well as on climate change and atmospheric deposition of nitrogen. Key component for evaluating ecosystem integrity is a classification of ecosystems containing data on indicators for ecological functions. Respective historical data covering 1961-1990 was regarded as reference. The assessment of ecological integrity relies on comparing a current or future ecosystem status quantified by indicators with respective historical reference values. Whilst historical and current ecosystem conditions were quantified by measurements, potential future developments were projected by geo-chemical soil modelling and data from a regional climate change model.

The ecosystem types were referred to the potential natural vegetation and mapped additionally using geo-data on current tree species coverage and land use. The current ecosystem types were related to geo-data (a.s.l. elevation, soil texture, air temperature, humidity, evapotranspiration, precipitation 1961-1990) by Classification and Regression Trees. The relations determined by this were applied to the above mentioned geo-data and then used to map the spatial pattern of ecosystem type clusters for 1961-1990. Then, the climate data 1961-1990 were replaced by results from a regional climate model for 1991-2010, 2011-2040, and 2041-2070. Accordingly, for each period one map of ecosystem type clusters were produced and evaluated with regard to the development of areal coverage of ecosystem clusters across time due to climate change. This evaluation of structural aspects of ecological integrity in terms of bio-geographical coverage on the national level was added by projecting potential future values of indicators for ecological functions at site-level. This was achieved by using the Very Simple Dynamics soil modelling technique using the above mentioned climate data and two scenarios of atmospheric nitrogen deposition as input. The results were compared to the reference and enabled evaluating site-specifically ecosystem integrity over time which proved to be both, positive and negative with regard to nature protection.

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## **The Phosphorus Paradox: Productive Agricultural and Water Quality**

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Agriculture's role in contributing phosphorus (P) to surface water impairment has increased due to recent high profile harmful algal bloom outbreaks. In addition, an inability to meet targeted nutrient load reductions in large basins, such as Chesapeake Bay, Lake Erie, and Mississippi River, has brought into question the effectiveness of current and future conservation strategies designed to mitigate such loads. Farmers in Canada and the U.S. remain among the most productive in the world, but projected population growth that is expected to be more affluent, will further pressure farmers to maximize yields. At the same time, increased pressures are being placed on farmers to be environmental stewards. However, despite a long history of soil and water P research, management questions still exist and water-use impairment continues as a result of P enrichment of soil-water systems. This leads to the recognition of several paradoxes related to the management of agricultural P.

### **A FINITE RESOURCE AND ENVIRONMENTAL ABUNDANCE PARADOX**

Phosphorus is a finite resource with an expected life of 300 years using modern mining technologies before currently known economically-extractable supplies are depleted. Despite the successes in achieving global P distribution, profound inequalities remain, with P deficits occurring across 30% of global cropland. Indeed, the poverty and food insecurity across the developing world is largely coincident with P deficits in agricultural soils. At the same time that we are dealing with potential food security issues with supplies of P containing ores limited to only a handful of countries, we are dealing with water quality impairment that has resulted from an overabundance of P in certain agricultural sectors. It is estimated that less than 20% of mined fertilizer P reaches the food products consumed and only 10% of the P in human wastes is recycled back onto agricultural land.

### **BLUE – GREEN PARADOX**

An increasingly affluent population is becoming more demanding of cheap, reliable food sources and wanting inexpensive clean, safe water for many essential and recreational uses. As we have moved from nutrient management that improves crop production to the water quality arena, we face many challenges in balancing competing demands for protecting and restoring water quality and aquatic ecology, with sustainable and efficient agricultural production. It is important to recognize that market prices do not always motivate farmers to manage nutrients in an

environmentally sustainable way. Consumers can be given a choice about which products they buy, with premiums paid to farmers who provide more environmentally friendly products.

However, after the low hanging fruit of remedial measures are adopted, remaining CPs become increasingly less cost beneficial and raise the old dilemma “who benefits and who pays?” Also, what level of water quality, or designated use, are we willing to accept in catchments with intensive land use changes? There are many cases where water quality and P reductions goals have been set and subsequently not met. This is usually due to intensive productive agriculture and urban activities occurring within leaky catchments with altered hydrology. That is not to say that ‘realistic’ water quality goals cannot be achieved. From the preceding discussion and examples, clearly practices are available that can minimize P runoff from productive agriculture in both the short and long term. However, they will not eliminate losses, and as recent studies in the Lake Erie Basin have shown - small losses of P (<1 kg/ha/yr) can still accelerate eutrophication; rather those losses must be managed.

## **CONSERVATION LEGACY P PARADOX**

Many conservation practices have been implemented to retain (e.g., no-tillage, cover crops, contour plowing, ridge tillage) and trap P (e.g., buffer strips, riparian zones, wetlands) on the landscape rather than enter waterways. Yet, the capacity of those practices to retain is finite and there are more and more examples of conservation practices transitioning from P sinks to P sources. Research that better quantifies the sinks and sources of nutrients as they are transported through a watershed, and the legacies and lags from past land use, will help develop realistic expectations for CP use and the timescales for aquatic ecosystem recovery.

## **SOIL HEALTH PARADOX**

Many important NRCS initiatives are promoting improved soil health as a major goal of future agricultural management practices. However, others claim that improved soil health can eliminate nutrient runoff and leaching are misguided. For instance, practices such as no-till can lead to a surface accumulation of applied P, which can enrich dissolved P runoff, as well as a greater potential for leaching through intact macropores, unless there is either a concomitant change in fertilizer and manure management or occasional soil destratification. With the push for more widespread CP adoption, these need to be based on field documentation.

The unintended consequences of certain CPs designed to either limit erosional loss of P or retain P on the landscape, need to be recognized when developing sustainable on-farm conservation strategies. In reality, there are no magic silver bullets when it comes to limiting P loss. While long-term monitoring in Maumee and Sandusky watersheds of the Western Lake Erie Basin document dramatic total P reductions with reduced tillage, the loss of more environmentally reactive dissolved P has increased.

## **THE GRAIN FOR FUEL PARADOX**

With increasing pressures to meet biofuel mandates, 42 and 25% of the corn and soybean grown in the U.S. was used to produce biodiesel in 2012. In some areas, CRP and environmentally

sensitive lands were allowed to go back into grain production; large tracts of land have been tilled drained, increasing source areas and connectivity of soils directly to streams and bypassing the soil matrix where P might have otherwise been sorbed; and in other areas crop residue is removed as biomass fuel increasing the potential for runoff and erosion.

## CONCLUSIONS

As phosphate rock resources become more expensive to extract and refine, new methods will develop for the concentration and recovery of P from current waste streams and manures. This includes struvite generation and use of amendments that can bind and precipitate P from manures of varying organic matter and liquid contents. With an increase in the cost of refined mineral fertilizer P, methods for recovered P not currently profitable will develop. Thus, new technology to recover P from manures needs to be explored, developed and refined. Clearly, it is not a question of if these technologies will be needed, but when.



## Periphyton Community Dynamics as an Indicator of Water Quality

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Periphyton, attached micro algae, respond rapidly to changes in environmental factors. As a result, periphyton are used as water quality indicators. Periphyton samples growing on small rock surfaces in the littoral zone were collected in replicates from thirty sampling areas in Central Ontario including: the Trent-Severn Waterway north of Lake Couchiching, Lake Simcoe, Bass Lake, Lake St. John, and the Holland River. The water parameters monitored at these sites include: pH, dissolved oxygen, temperature, conductivity, chlorophyll-*a*, total suspended load/biomass, nutrients (total phosphorus and total nitrate). Periphyton samples extracted by using sterile toothbrushes from the rock surfaces were studied for their density, biomass, microalgae species composition, species diversity, and bio-volume. Overall, more than 80 different species of microalgae were found. The dominant species found were *Cymbella sp.*, *Diatoma sp.*, *Navicula sp.*, and *Synedra sp.* Of these dominant species, *Navicula sp.* was the only one species found in all samples that were counted. The presence of *Oscillatoria* and *Achnanthydium sp.* found at the outflow of Orillia's wastewater treatment facility well represented the high concentrations of nitrate, high conductivity, and flowing waters. Similarly, the presence of *Anabaena sp.* at Lake St. John well represented high nutrient availability and chlorophyll *a* concentrations within the lake. Significant variation was observed in species composition between sampling locations. Species richness varies from 4 to 37, and Shannon's Diversity Index range from 0.17 to 1.02. Site 1, Line 14 in Oro-Medonte, had the lowest species richness whereas site 17, Harbour Park Crescent, had the highest species richness. Site 1 also yielded the lowest species diversity, while site 25, Centennial Park in Washago, had the highest species diversity. Overall, the significant variation in species composition, richness, and diversity will help in designing periphyton based water quality index for this region.

## Biomonitoring of Wastewaters Based on Assessment of a Functional State of Crayfish

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The assessment of the quality of wastewaters into surface waters is very important to maintain ecological healthy status of water bodies. In accordance with official regulations, all the existent technologies of biological purification do not allow complete removal of many toxic and persistent chemical compounds that are capable of bioaccumulation, especially at low concentrations like pharmacological substances. The way to minimize such environmental impacts on the integrity of aquatic ecosystems is to recycle sewage waters of such quality at which they do not affect normal functionality of hydrobionts. Use of living organisms as bioindicators and characteristics of their functionality as biomarkers will allow us to assess both known (identified) and unknown substances (including possible synergetic effects). Nowadays biocontrol of sewage water toxicity is normally done by traditional bioassay methods as growth suppression in some algae species, decrease of mobility and/or survival in laboratory cultures of *Daphnia*, luminescent inhibiting in bacteria. However, those methods do not allow having continuous real-time monitoring the quality of wastewaters.

A non-invasive fiber-optic method for cardiac activity registration in crayfish has been developed previously by Kholodkevich et al. (2008). This method gives an opportunity to control continuously, remotely and in the real time the animals' functional state and, hence, to assess the quality of surface waters as a habitat of hydrobionts. Particularly, a bioelectronic system for industrial biological monitoring of sewage water quality (SIBMSWQ) based on this method was developed and used in industrial operation since January, 2011 at the South-West Wastewater Treatment Plant (SWTP), Wastewater Disposal Branch of SUE "Vodokanal of St.Petersburg". Two species of fresh water crayfish were used as bioindicators: aboriginal for the North-West of Russia *Astacus leptodactylus* (during cold season) and Australian crayfish *Cherax quadricarinatus* (during summer season). Characteristics of their cardiac activity (the heart rate, a variation pulsometry characteristic - the stress index, expressing regulatory systems stress level, together with circadian rhythm) are used as biomarkers. SIBMSWQ includes 6 aquariums with one animal in each. Biologically purified sewage water flow continuously through the monitoring system. Continuous data collection also allowed analysis of chronic effects of the controlled water for arbitrary period of time. Accepting as a rule that acute toxicity should be excluded completely (what we observed during a 4-year industrial experiment of SIBMSWQ) and taking into account synergism of different component of sewage water as well as their bioaccumulation capacity, the assessment of chronic effects became very important. That is why one may recommend to perform monitoring of chronic effects of sewage water on bioindicators using animals. The continuous

control of crayfish cardiac activity conducted permanently during four years showed that cardiac characteristics in daylight and nocturnal periods corresponded to the ones observed in pure water in laboratory conditions. After a half year study at SIBMSWQ, crayfish were tested in laboratory condition with use of functional load method. Similar approach was used by Bamber and Depledge (1997) while evaluating the functional state of shore crabs *Carcinus maenas* taken from several contaminated localities. Physical stress (suspension) did not reveal any significant changes in functional state crayfish. Particularly, the crayfish possessed typical circadian rhythm in cardiac activity and demonstrated standard response to suspension (Sladkova et al. 2012). Good feeding, locomotion activity as well as normal moulting also indicated a good functional state of the organisms.

In conclusion, the use of bioelectronic monitoring systems to assess acute and chronic effects of the biological action wastewater on aquatic organisms could be very useful.

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## **Using Agri-Environmental Indicators to Communicate Risks to Water Quality from Horticulture Production in Ontario**

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Improved environmental quality in the agricultural landscape is directly tied to how farmers manage their land. Farmers make management decisions within the context of the constraints in their production systems. Farm constraints include: soil type, variability, and slopes; micro-climate; the crops grown, their rotation, nutrient demand, tillage regime and equipment required; and the economics of viability. Farms with similar constraints can be grouped into defined production systems. Understanding the capacity for environmental improvements at a production system scale allows farmers, farm organizations and policy makers to prioritize and benchmark investment in programs, practice change, research and technology transfer to affect improved environmental performance.

This project developed a practical, systematic and science-based “production system framework” model to evaluate the hypothesis that different production systems have differing capacities to affect environmental improvements. A typology or rule set was applied to individual Canadian Census of Agriculture, 2011 records to group farms into defined production systems. Census output values for each system were combined with grower practice survey data, the most relevant research literature values, and local climate data to calculate the following water quality and quantity related agri-environmental indicators: nitrogen balances, phosphorus balances, soil erosion, crop water demand, irrigation water demand and point source wastewater impacts.

Indicator results are presented using three contexts: impact per area, impact per unit yield, and impact per dollar of economic contribution. Fifteen different Ontario based horticulture (fruit, vegetable, ornamental and specialty crops) production systems were evaluated. Ontario horticulture organizations were consulted to ensure the input data is reflective of Ontario production realities and to facilitate the transfer of resulting knowledge to the sectors.

Results demonstrate that different production systems have different priority environmental issues and that the range of impact for one environmental metric can be very broad. For example nitrogen and phosphorus balances were found to vary from below 0 kg/ha to over 3000 kg/ha depending on the production system.

## Antioxidants in Glutathione-Ascorbate Cycle as Early Warning Indicators to Toxicity of Bde-47 in Mangrove Seedlings

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Polybrominated diphenyl ethers (PBDEs) are common brominated flame retardants that have been detected in various environmental matrices and biological samples, and the burdens have been rising rapidly in recent years. PBDEs, the same as other persistent organic pollutants (POPs), are likely to cause the over-production of reactive oxygen species (ROS) leading to the peroxidation, membrane damage and inactivation of enzymes. Higher plants are known to have the ability to scavenge excess ROS and combat the oxidative stress. The glutathione-ascorbate (GSH-AsA) cycle, involving enzymes such as ascorbate peroxidase (APx), glutathione reductase (GR) and glutathione peroxidase (GPx), is one of the defense systems protecting ROS-mediated oxidative damage in many cellular compartments (Aravind and Prasad, 2005; Caregnato *et al.*, 2008; Anjum *et al.* 2012). The antioxidant parameters in the GSH-AsA cycle were found to be related to the stresses of various toxic metals, metalloids and polycyclic aromatic hydrocarbons (PAHs), but the changes appeared to vary from plant to plant and from stress to stress (Anjum *et al.* 2012). Mangrove plants commonly found in inter-tidal zones along tropical and subtropical coasts provide significant ecological services but are subject to various stresses. The GSH-AsA cycle of mangrove plants changed when exposed to environmental stresses producing excessive ROS, such as fluctuating salinity, water logging, heavy metals, PAHs and oil pollution (Song *et al.*, 2012). For instance, the activities of GPx in *Avicennia marina* and *Kandelia candel* were induced by heavy metals, suggesting that GPx could act as an early warning biomarker; however, such stimulation was not found in *Bruguiera gymnorhiza* (Caregnato *et al.* 2008; Huang *et al.* 2010). How mangrove plants defend themselves against oxidative stresses posed by PBDEs and whether the GSH-AsA cycle related antioxidants provide a warning to the toxicity of PBDEs in mangrove plants is still poorly understood.

The present study aims to investigate how the GSH-AsA cycle related antioxidants in the seedlings of *Kandelia obovata* (Ko), a dominant true mangrove plant species in South China, changed under the stress of BDE-47 and identify the early warning biochemical indicator in the cycle to the toxicity of PBDEs. BDE-47 is the main component of a popular commercial product, Penta-BDE, and is one of the most prevalent and toxic PBDE congeners in the environment according to a file from the US Environmental Protection Agency. This congener has also been added to Annex A of the Stockholm Convention, which aims to protect human health and the environment by eliminating toxic POPs. An 8-week hydroponic culture experiment, planted with one-year old seedlings of Ko with five contamination levels of BDE-47, that is, 0, 0.1, 1, 5 and 10 mg/L, was conducted. In the first week, the activities of APx, GR, GPx and the content of dehydroascorbate (DHA), an oxidized form of ascorbate (AsA), in the root and leaf were induced, while the content of AsA was reduced by the two high levels (5 and 10 mg/L). All these enzymes

and antioxidants in the seedlings exposed to BDE-47 treatments became the same as the controls in weeks 4 and 8, suggesting a gradual recovery of these antioxidants with time. On the other hand, the content of reduced glutathione (GSH) and the ratio of GSH/GSSG in the root and leaf were enhanced by 5 and 10 mg/L BDE-47 in weeks 1 and 4, while their oxidized glutathione (GSSG) were decreased, but no differences were found in these parameters among all treatments in week 8. This suggests that the BDE-treated mangrove seedling was under an oxidative stress and the plants had to maintain a high content of GSH and a high GSH/GSSG ratio to combat the stress. The gradual return of the antioxidants in the cycle to the same levels as the control in weeks 4 and 8 implied that the defence mechanism of Ko seedlings might have been broken down after long-term exposure to high levels of BDE-47 contamination.

The growth of mangrove seedlings, in terms of leaf, root and total dry biomass, was suppressed at the two high BDE-47 levels (5 and 10 mg/L) from weeks 4 to 8, implying that plant growth was affected as the GSH-AsA antioxidant defence system of Ko might be inadequate to counter-balance the oxidative stress induced by high levels of BDE-47. Similarly, Caregnato *et al.* (2008) also found that the glutathione antioxidant defence system in *A. marina* was perhaps inadequate to stave off the oxidative stress elicited by zinc at later intervals. It is clear that growth reduction was detected at the end of the 8-week exposure but changes in the enzyme activities and the content of antioxidants in the GSH-AsA cycle, especially those in the root and leaf, were observed almost immediately after exposure, from day 4 onwards. Caregnato *et al.* (2008) also concluded that an accumulated pollutant acted first at the biochemical level and the related responses were later reflected at higher levels of biological organization. Significant positive correlations were found between the antioxidants in week 1 and the final biomass in week 8. The results of stepwise multiple regression further revealed that the most sensitive and important indicators in the GSH-AsA cycle were AsA and GPx. The present study is the first research demonstrating that the GSH-AsA cycle related antioxidants, particularly AsA content and GPx activity, were sensitive indicators and provided early warning to the toxicity of PBDEs on mangrove plants.

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## **Land Cover Monitoring (2006-2010) of Three Pacific Northwest Ecoregions of the United States to Explore the Application of the WELD Landsat Data**

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Composite mosaics of Landsat images recently have become available that offer many advantages, but it is unclear how valuable they are in detecting and measuring regional land cover change. We compare mosaics from the Web-enabled Landsat data (WELD) to the U.S. Geological Survey Land Cover Trends manually interpreted land cover in three Pacific Northwest ecoregions. We found that the land cover change across study area was 2.3 percent with an annual change of 0.46 percent. The land cover fractions of the WELD Landsat and the USGS Land Cover Trends block maps showed a correlation of 96 percent. Spatial comparison between the WELD Landsat map and the Trends maps yielded an overall agreement of 89 percent with a kappa coefficient of 0.85. The results show that WELD has a high potential for land cover monitoring, especially in forested areas.



## How Damming Is Modifying Riverine Nutrient Fluxes

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The damming of rivers represents one of the major anthropogenic disturbances of the natural cycles of water and nutrient elements on the continents. The associated changes in both the absolute and relative riverine fluxes of nutrients have far-reaching ecological implications, from individual ecosystems to the global biosphere. While dam reservoirs usually act as sinks of macronutrients along the river continuum, their effects on riverine fluxes and chemical speciation differ markedly from one nutrient element to another. Dams thus fundamentally alter nutrient stoichiometry and limitation, trophic conditions, and water quality in river ecosystems and receiving water bodies, including large lakes and coastal marine environments Van Cappellen and Maavara (2015).

In this study, we review past and near-future trends in dam construction, and discuss the corresponding effects on the retention of nitrogen (N), phosphorus (P) and silicon (Si). Results from recent studies on the cycling dynamics of N, P and Si in Lake Diefenbaker, a 400 km<sup>2</sup> reservoir on the South Saskatchewan River, illustrate the decoupling of riverine nutrient fluxes caused by the presence of dams (Maavara et al. 2015). This decoupling is also apparent at the regional scale when comparing the retention of N and P by reservoirs for the entire Lake Winnipeg watershed (Donald et al. 2015). In order to assess the global scale effects of dams on riverine nutrient fluxes, we use a knowledge-based upscaling approach (Van Cappellen 2015; Maavara et al. 2014) that combines available data on elemental budgets for individual reservoirs, mechanistic models of nutrient cycling in surface water bodies, and the stochastic analysis of the model outcomes. The approach is applied to estimate the temporal and spatial changes in P retention by dams during the 1970-2030 period. Particular attention is given to the potential future reduction of P loading to rivers associated with the recent surge in dam construction, especially concentrated in South America, central Asia, Africa and Southeast Asia.

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## **Sensitivity and Uncertainty Analysis of Epic to Simulate Phosphorus Loss from Agricultural Land in Ontario**

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Phosphorus (P) losses from non-point sources through runoff and tile drain flow into water bodies play a significant role in eutrophication. Nowadays there are many well established models to describe P loss, however, still many deficiencies for modelling P loss. Environmental policy integrated climate model (EPIC) has been used to simulate the P loss from runoff and subsurface drainage based on experimental data from 2008 to 2011 at Harrow, Ontario. Global sensitivity analysis was used to determine the preferential parameters at this specific location. And generalised likelihood uncertainty estimation (GLUE) was used for calibration and uncertainty analysis. Hydraulic parameters showed low contribution to the model output uncertainty, such as saturated hydraulic conductivity, soil water content at field capacity and wilting point, which may reveal the incapacity of EPIC to simulate P loss from subsurface drainage due to underestimation of P leaching through the soil. The possible reason is that EPIC weight too much on soil mixing to simulate P downward transport. Another possible mechanism was because estimation of P leaching was defined as the ratio of soil labile P concentration to P concentration in percolating water, which is partly depending on the accuracy of initial soil labile P. Estimation accuracy of the initial concentration of soil labile P and P sorption coefficient (PSP) are crucial for the correctness of EPIC simulations. Site specific determination of labile P and PSP derived on soil properties based on pedo-transfer functions would increase the accuracy of EPIC to simulate P loss from runoff and subsurface drainage.

## **Determination of Spacial Erosion Risk Distribution for Management and Planning in Yeka Ankorucha Catchment Using ‘Rusle’ Model, GIS and RS, Addis Ababa, Ethiopia**

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The use of RS and GIS techniques integrating with RUSLE makes soil erosion estimation and its spatial distribution feasible with reasonable costs and better accuracy in larger area. Such methods provide significantly better results than using traditional methods of measuring and calculating Erosion related biophysical data on the field. Human activities such as urbanization and industrialization and the respective land use change within a basin is one of the contributing factors, which cause deterioration of river water quality through its potential effect on erosion. Sediment yield in the form of suspended solid in the river water body, which is transported to the downstream area, occurs as a sign of lowering of the water quality. Hence, the aim of this study was to determine potential soil loss using the Revised Universal Soil Loss Equation (RUSLE) model in Geographical Information Systems (GIS) environment within selected catchment of Awash River Basin. RUSLE was used to estimate potential soil losses by utilizing information on rainfall erosivity (R) using interpolation of rainfall data, soil erodibility (K) using soil map, vegetation cover (C) using satellite images, topography (LS) using DEM and conservation practices (P) using data collected by GPS for the conservation actions made in the area. The results indicated that the rate of potential soil loss in Yeka Ankorucha catchment, Ethiopia ranged from very low to sever. The area covered by low to moderate potential soil loss was about 51%, whereas moderate to soil loss potential covered about 49% of the study area.

## **Different Nitrogen Forms and Denitrifying Bacteria Space Distribution Characteristics in Surface Sediments of Different Outfalls of Nanfei River**

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In the process of the migration and transformation of nitrogen, sediments play an important role as the source and sink, and denitrification is a significant way of sediment nitrogen removal. However, only convertible nitrogen, so-called effective nitrogen in sediments could participate in the nitrogen cycle with the action of microorganisms.

In order to investigate the potential risk of nitrogen release and the difficult degree of nitrogen removal in surface sediments of Nanfei River, a typical urban river in Chao Lake Basin, China, the surface sediment of four types of outfalls, including rainwater outfalls, rainwater and sewage outfalls, tributaries outfalls and sewage plant outfalls, were sampled and researched. Through the chemical grade leaching, nitrogen is in turn classified into ion exchangeable form (IEF-N), weak acid extractable form (WAEF-N), strong alkali extractable form (SAEF-N), strong oxidant extractable form (SOEF-N), and residual nitrogen (RES-N). The first four are transferable form nitrogen (TF-N), while RES-N hardly participates in the cycle of nitrogen because of being difficultly used by microorganisms. On the other hand, real-time fluoresce quantitative polymerase chain reaction (FQ-PCR) and terminal restriction fragment length polymorphism (T-RFLP) are used to analyze the quantity and spatial distribution characteristics of denitrifying bacteria. Then, we discuss the relationship between denitrifying bacteria and different forms of nitrogen and other environmental factors through Monte Carlo Test and Redundancy Analysis.

The results show that the content of TF-N in surface sediments from big to small in proper order is tributaries outfalls, rainwater and sewage outfalls, sewage plant outfalls and rainwater outfalls, but the difference is not obvious between different types of outfalls, and IEF-N has the highest content of TF-N for all kinds of outfalls. There is a greater difference between the numbers of denitrifying bacteria in the surface sediments of different outfalls. Denitrifying bacteria strains with gene fragment length from 187.33 bp to 187.48 bp and from 188.32 bp to 188.46 bp in T-RFLP map are the ubiquitous strains, which are also the dominant species. For different outfalls, there are no specific denitrifying bacteria strains. According to Monte Carlo Test and Redundancy Analysis, TF-N has a deep influence on the spatial distribution characteristics of denitrifying bacteria, and rainwater and sewage outfalls could provide much more carbon sources, nitrogen sources and energy sources for denitrification, while sewage plant outfalls provide the least of all.

In conclusion, there is a largest content of TF-N in the surface sediments of tributaries outfalls, which has a highest potential release risk of nitrogen when in the adapted conditions. For surface sediments of rainwater and sewage outfalls, nitrogen is easy to denitrification, because seeing from the conditions and mechanism of denitrifying, surface sediments of rainwater and sewage outfalls have sufficient carbon sources, nitrogen sources and energy sources, while surface sediments of sewage plant outfalls are on the contrary, which should be controlled and governed seriously.

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## **The 2050's Great Lakes Area Climate Change (Temperature and Precipitation) Forecast: Based on PRECIS High Resolution RCM (25 Km x 25 Km) Analysis Results**

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The Laurentian Great Lakes contains about one-fifth of the world's surface freshwater and eight-tenth of North America. The climate changes of this area may affect water supply, tourism, shipping, fish resources and many other issues in North America. In this study, we applied a Regional Climate Model - PRECIS, which developed at Hadley Centre of Met Office of UK to generate a high resolution (25 km x 25 km) of future climate conditions for the Great Lakes basin. The PRECIS was validated by some observed climate data and future climate conditions were projected based on the SRES\_A1B Emissions Scenario. Our analysis shows that future (2050s) Great Lakes area temperature may increase 3.25 °C in winter and 2.87 °C in summer respectively. For the 2050s winter precipitation (snow) of upper and lower Great Lakes area may averagely increase 0.4 mm/day and 1.0 mm/day respectively, and the 2050s summer precipitation of upper and lower this watershed may also increase 0.2-0.3 mm/day and 0.7 mm/day respectively. Our further research will utilize those climate change data to study the impacts of climate changes on the Great Lakes fish habitats.

## Water Stratification is Key to Form Algal Bloom in the Backwater Area of the Three Gorges Reservoir, China

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The Three Gorges Dam has backed up water to varying depths in the catchment tributaries after impoundment which has resulted in slow flow and an accumulation of nutrients in the backwater areas. Since 2003, the reservoir started to store water, and algal blooms developed immediately in the tributaries ranging from a short time periods to several months in a year. In order to determine the relationship between the water environment and algal bloom development, a high frequency sampling study at fixed site was carried out from April to December 2013 in Gaoyang Lake, the backwater area in Pengxi River, the largest river in the north bank of Yangtze River in the Three Gorges Reservoir catchment.

A clear thermal stratification was observed in the spring, summer and autumn vertical profiles of the water column, but not winter during the deep water phase where isothermal mixing was occurring (Fig. 1). The mixing layer depth during stratification ( $Z_{mix}$ ) changed from 3.8 m to 10 m depth (Fig. 2). The annual water euphotic layer depth ( $Z_{eu}$ ) ranged from 1.35 m to 9.45 m, and maintained 3 m from May to September. In the stratified water, especially during in the middle of April when the algal bloom was predominant, peaks of Chla in surface water occurred shortly after the maxima of  $Z_{eu}/Z_{mix}$  in the water column (Fig. 3), demonstrating that in highly eutrophic waters like that in Gaoyang Lake, stratification and high ratio of  $Z_{eu}/Z_{mix}$  strongly attributed to the development and persistence of algal blooms.

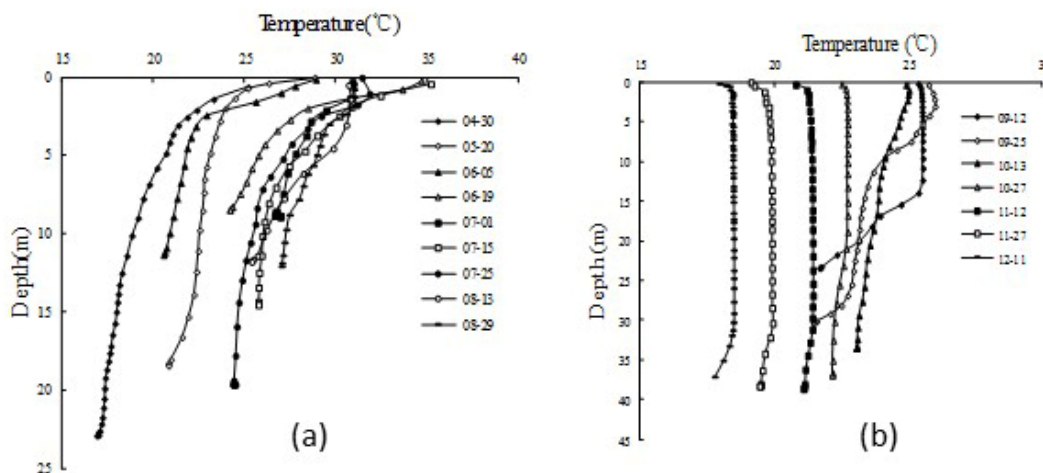


Figure 1. The temperature curves in vertical distribution in Gaoyang Lake. (a): Low water level; (b): High water level.



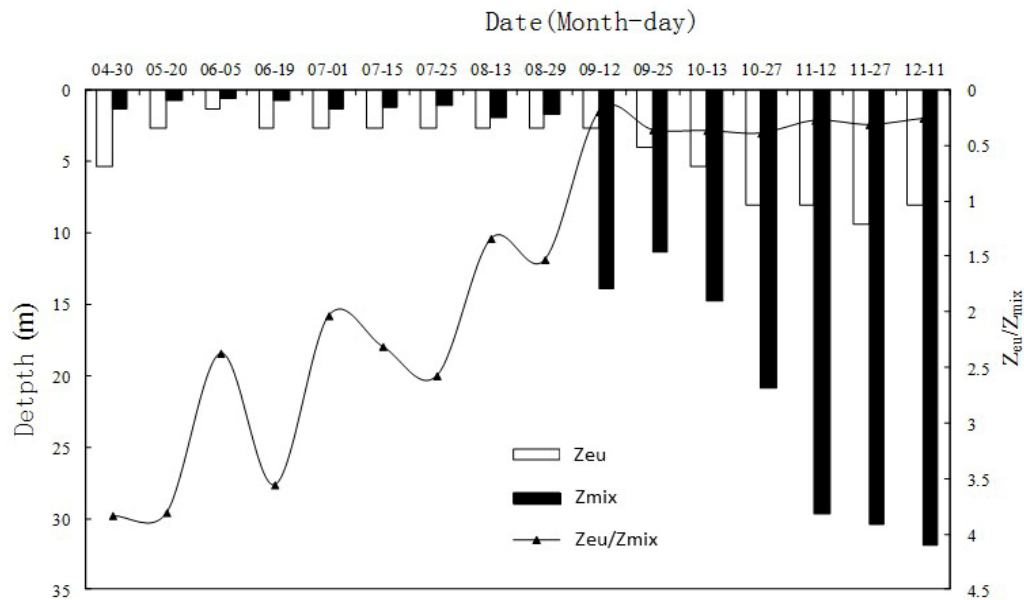


Figure 2. Variation of  $Z_{eu}$ ,  $Z_{mix}$  and  $Z_{eu}/Z_{mix}$  in Gaoyang Lake.

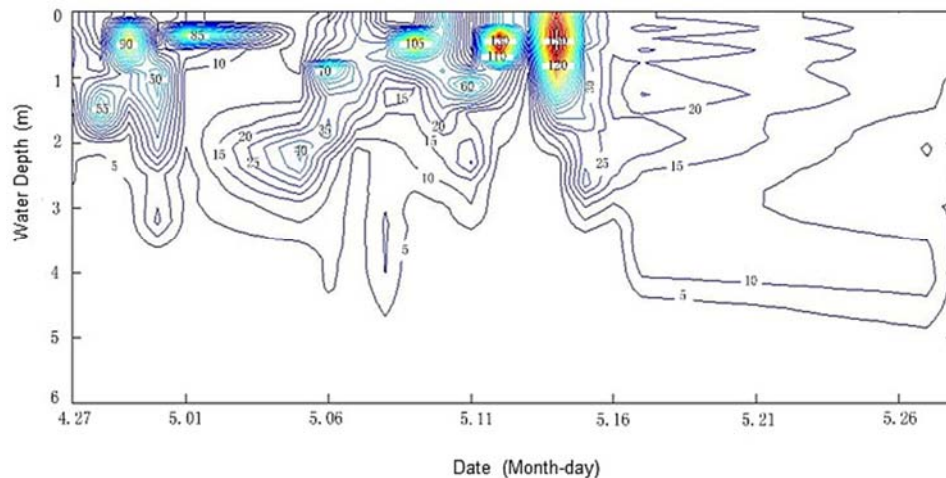


Figure 3. The spatial and temporal isoclines map of concentration of chlorophyll ( $\mu\text{g/L}$ ) on permanent backwater area of the Pengxi River.

In late spring, during the algal bloom, the algal community was composed of 9 genera of 4 divisions, while the average cell abundance in surface water was  $2284 \times 10^4$  cell/L, mainly composed by *Cyanophyta* and *Chlorella* groups, and the dominant genera were *Microcystis*, *Pandorina* and *Eudorina*. However, in the winter when the waters of Gaoyang lake were not stratified, the dominant genera were *Cyclotella* and *Synedra*, and algal density was much lower with a maximum biomass of  $14 \times 10^4$  cell/L and the average cell abundance in different depths of the water column layers was similar. Gaoyang Lake water stratification affects the growth and distribution of algal community.

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## Trees Carbon Sequestration of Different Reclamation Patterns in Antaibao Opencast Mine, Shanxi, China.

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Reforestation is often selected in the reclamation of mined land for tree's property of creating easily biomass, new self-sustaining topsoil and controlling erosion, so recovery of reclaimed vegetation has a great significance on carbon sequestration. Based on the permanent plots (1 hm<sup>2</sup> for each plot) of three different reclamation patterns reclaimed at same time (1992), Locust (*Robinia pseudoacacia*), elm (*Ulmus pumila*), heaven tree (*Ailanthus altissima*) mixed forest (plot *SIII*), locust-pine (*Pinus tabuliformis*) mixed forest (plot *SIV*), and pure locust forest (plot *SV*), in Antaibao (ATB) opencast mine, trees carbon sequestration of the three different reclamation patterns was studied using the forest stock volume formula method. The results showed that *SIV* has the highest density of tree's volume, reached 45.00 m<sup>3</sup>/hm<sup>2</sup>. The tree's volume density of *SIII* was 24.39 m<sup>3</sup>/hm<sup>2</sup> and that of *SV* was 21.44 m<sup>3</sup>/hm<sup>2</sup>, which was in an increasing order of *SIV*>*SI*>*SIII*>*SV*. Accordingly, carbon sequestration among these plots was in the order *SIV*>*SI*>*SIII*>*SV*. *SIV* has the highest carbon density, 27.54 t/hm<sup>2</sup>, which is higher than the national average carbon density of artificial forests (22.17 t/hm<sup>2</sup>), but lower than the average artificial forest carbon density in Shanxi Province (31.75 t/hm<sup>2</sup>), and *SV* has the lowest carbon density 17.95 t/hm<sup>2</sup>. The mixed forest showed an obvious higher carbon sequestration capacity than the pure forest which is in agreement with our other study results on the plots. Between the two mixed forests, locust-pine pattern is better than locust- elm -heaven tree pattern in carbon sequestration capacity, indicating that rational or scientific configuration of tree species to meet the trees species' biological property and the rule of interaction between them is an important issue in reclamation.

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