Trends in Environmental Science

Henry C. Schroder
Editor

Environmental Research Advances

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PREFACE

The environment is considered the surroundings in which an organism operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation. It is this environment that is both so valuable on the one hand, and so endangered on the other. And it is people that are by and large ruining the environment, both for themselves and for all other organisms. This book presents some of the latest research in the field.

Chapter 1 - Three main aspects of the possible impacts of retreating pack ice and changing ice coverage in the European Arctic on the higher trophic levels are discussed in this chapter:

1. Seabirds are depending on their colonies on land during the breeding season; the main species, e.g., little auk *Alle alle,* feed in mixed Polar/ Arctic Water in order to bring back food (polar zooplankton) to their chicks on the nest. In case ice coverage is very low, distance between colony and feeding grounds might become too long for such daily trips, and little auks might have to interrupt breeding and massively leave their colonies before the end of the reproduction cycle (e.g., on Jan Mayen in July 2005). On a longer term, if ice coverage was decreasing too much in future years, the whole Spitzbergen population might be affected, as well as other seabird species feeding mainly at the ice edge.

2. Stocks of large whales were close to depletion in the north-eastern Atlantic due to massive over-exploitation by whaling, and to their separation from the more abundant North Pacific stocks by high ice coverage of both the North-East and North-West Passages. In the frame of our long-term study of the at-sea distribution of seabirds and marine mammals in Arctic seas from 1979 on, resulting in more than 10,000 half-an-hour transect counts, an important increase of the north-eastern Atlantic stocks was detected from 2007 on, the year with lowest ice coverage, mainly for bowhead *Balaena mysticus,* blue whale *Balaenoptera musculus,* humpback whale *Megaptera novaeangliae* and fin whale *Balaenoptera physalus.* Such a sudden and important increase cannot be attributed to population growth, but to a probable inflow from the more abundant Pacific stocks, the decrease of ice coverage allowing the opening of the Passages.

3. On the other hand, polar bear *Ursus maritimus* and its prey: pinnipeds - mainly harp seal *Pagophilus (Phoca) groenlandica* - seem not to show any important decline of their population, with a few local exceptions. Moreover, encountered bears regularly concerned mother with cub(s), which also reflect the good health status of the population. The reason is probably that they are not bound to pack ice as such, but to the Outer Marginal Ice Zone

(OMIZ): they are almost absent in the Closed Pack Ice (CPI). They seem to adapt and follow the OMIZ, even when its position is influenced by changes in ice coverage.

These data collected on board icebreaking *RV Polarstern* are discussed in this chapter, in function of changes in ice coverage, in the extent of the main water masses and thus in the position of the ice edge and fronts.

Chapter 2 - Nematodes are the most abundant and arguably the most diverse metazoans on Earth. The great importance of this group in the marine sediments is not only related to their dominance in terms of both abundance and biomass, but also to its close relationship with the other organisms playing a key role in the trophic webs. The effects of nematodes on sediment stability are similarly crucial. In coastal systems and oceans, the causes of local and regional environmental changes can be various. The relative stability of populations, the short turnover rate and the generally high tolerance to ecosystem alterations make Nematoda particularly suitable as bioindicators, a benefit that is enhanced because collection methods and sample treatment for these species are relatively simple. It is for this reason that this phylum was used as an indicator for assessing the ecological quality of marine ecosystems according to the Water Framework Directive (WFD, Directive 2000/60/EC). In addition, the high taxonomic diversity of nematodes is also related to their large trophic spectrum and the variety of their buccal structures. The latter, and other traits such as body and tail shape and life strategy, are easily recognizable, meaning that nematodes can be distinguished on both a morphological and functional basis. Functional diversity is an important component of biodiversity, although if compared to taxonomic diversity, it is still poorly applied.

Nevertheless it could be very promising when it comes to improving the author's knowledge of ecosystems and relationship between the diversity patterns of nematodes and the abiotic environment. Recent studies have suggested that biodiversity loss might impair the functioning and sustainability of ecosystems. Accordingly, monitoring the quality of the environment appears to be essential for devising effective protection strategies and appropriate forms of management.

Chapter 3 - This paper describes the systematic approaches used for making retrospective prediction (retrodiction) of the environmental quality (EQ) of three downstream riparian communities associated with two dams in Kumasi, Ghana. The first step consists in applying parametric and nonparametric cross validations (CVs) as model selection tools to evaluate their predictive powers over specified time lags (i.e., 1957→1958, 1966 →1967, 1972→ 1973, 1999→ 2000), using the environmental quality indices (EQIs) and operational activity indices (OAIs) constructed in the Paper I, as essential ingredients. An attractive component of the entire modeling processes is that the use of the indices which had been generated using an orthogonalization process via a standard non-rotated empirical orthogonal function (EOF) analysis circumvents the problem of multicolinearity in the CV process. However, constrained by short data records, the model selection methods were enhanced using computer-assisted simulations (for generating "artificial data" based on random numbers), fed by the indices. The inclusion of "artificial data" was also intended to put the two models on the same evaluation platform. By limiting the number of predictors (OAIs) to three, the "curse of dimensionality" is sidestepped, thus ensuring a good fit. The predictive powers of the parametric and nonparametric models were evaluated based on a part of the calibration datasets via a resampling CV technique, an approach recommended elsewhere for dealing with limited data. The CV outcomes indicated that the nonparametric model demonstrated a more capability than the parametric, and thus better fits the data. The inherent error detected

in one of the scenarios for the parametric model signified that it would have been a superfluous activity had we further embarked to evaluate the performance of the two models using the likelihood-ratio test author had planned for. The nonparametric outputs were then selected for the AR (1) model development, to evaluate the communities' EQ over the four scenarios. This model theoretically and consistently depicted highly positive first-order Markovian dependencies in the EQ of three out of the four lead year predictions, based on EQI (predictand) 1 baseline conditions. The magnitudes of these dependencies are a manifestation of deteriorations in the EQ (i.e., 1957→1958, 1972→1973, 1999→2000), on the basis of high environmental persistence. These results further demonstrated that the communities' EQ, to a large extent, was driven by the dams' operational activities (OAs), the most important event flagged when the two dams operated simultaneously, which further supports the author's hypothesis in the Part I study. However, the non-correlation between 1966 and 1967 EQ depicted randomness, which could not be associated with the operational impacts of the dam(s). However, author suspect a dominant role of natural variability over the operational impacts of dam(s) as of that time. The lack of observational data to realistically evaluate the models was one of the author's challenges. However, the magnitudes of the model biases, coupled with low RMSEs, demonstrate acceptable model performances, which have helped us gauge, to a reasonable extent, the communities' EQ, under different time lags, and under different phases of the dam(s).

Chapter 4 - All of the energy on our planet comes virtually from one source, the sun, and is storied via photosynthesis by green plants, cyanobacteria, and algae on the large scale at room temperature and neutral pH. Solar energy is sufficient to meet our current global need. Use of solar energy is completely carbon-free and is able to eliminate current concerns on the energy crisis and global climate change. A deep understanding of photosynthesis is the key to provide a solid foundation to facilitate the transformation from carbon-based energy source to sustainably solar fuels. The energy from the sun can be stored via water splitting, which is a chemical reaction through chemical bond rearrangement to convert the energy-deficient water molecule to energy-rich oxygen and hydrogen molecules. Water splitting chemistry is driven by sunlight in the reaction center of photosystem II located in the thylakoid membranes of plant leaves. The three-dimensional structures of photosystem II with oxygen-evolving activity have been determined at an atomic and a molecular level in the past ten years. To mimic the water splitting of photosystem II oxygen evolving complex, appealing systems including earth abundant element catalytic materials were discovered. In this chapter, recent progress in solar fuel production emphasizing on the development of Mn-oxo complexes and Co-phosphate catalytic systems were summarized and discussed. These systems, including Mn-oxo tetramer/Nafion, Mn-oxo dimer/TiO_2, Mn-oxo oligomer/WO_3, Co-Pi/Fe_2O_3, and Co-Pi/ZnO were, show a compelling working principle by combing the active Mn-oxo and Co-based catalysts in water splitting with semiconductor hetero-nanostructures for effective solar energy harnessing. The protocols are suit for preparing earth-abundant metal/semiconductor catalysts and highly likely open a new area of fabricating next generation of highly efficient water splitting catalysts to store the energy from the sun. Although the great challenge in these works is the dramatic improvement in efficiency and durability for its practical application, the progresses provide a promising scaffold and benchmark for achieving our goal to transform the solar fuels into our future energy systems.

Chapter 5 - In the present study characterization of municipal solid waste (MSW) is carried out for ten months at Urali Devachi landfill of Pune city, India. Characterization

shows that it contains 69.30 % of degradable organic matter. The decomposition of organic components in landfill produces landfill gas (LFG). Three landfill gas emission models have been used to estimate emission of landfill gas, based on MSW composition, total amount of MSW dumped and waste age. The models used are first-order decay (FOD), default methodology (DM) and modified triangular method (MTM). These models differ in their scientific approach for the quantification on emissions, their complexity and input data requirements. The emission of methane estimated for the year 2008 using FOD (Base), FOD (Worst), DM and MTM is 6.906 Gg, 10.299 Gg, 8.121 Gg and 5.095 Gg respectively. A comparison of FOD with recently proposed MTM shows that MTM model can be used for the estimation of methane generation. Methane generation for landfill was forecasted upto year 2023. Although the study is focused to Pune city, the investigations will be useful to compare and frame the policy to control the greenhouse gas emission from landfill in metropolitan cities in the Asian continent.

Chapter 6 - *Fusarium* species are soil borne vascular wilt pathogens, which are among the most important phytopathogenic and toxigenic fungi. They are filamentous and belong to the Class Ascomycetes and Family Hypocreaceae. *Fusarium* species typically produce macroconidia and microconidia, as well as mycelia and chlamydospores that serve as propagules in infecting host plants. The life cycle can be divided into dormant, parasitic and saprophytic stages. Most species are harmless saprobes; some species are parasitic, with some producing mycotoxins on plants. The pathogenic strains have high level of host specificity which has led to the development of the "formae specialis" concept. Each formae specialis can be further sub divided into races, on the basis of virulence in a set of differential cultivars within the same plant species. *Fusarium* wilt is a major concern in agriculture as it causes great economical losses in a wide variety of crops. The symptoms of *Fusarium* wilt range from stunted growth, yellowing and wilting of the leaves, reddish discolouration of the xylem vessels (visible inside the stem as lines or dots in cross section) and white, pink or orange fungal growth on the outside of affected stems (particularly in wet conditions), to root or stem decay.

There is remarkably little knowledge available about the molecular mechanism and/or pathogenicity genes required by *Fusarium* species to cause disease and how hosts combat or tolerate the pathogen. The genomes of some *Fusarium* species have been sequenced and comparative genomic analyses have shown that pathogenic *Fusarium* species consist of a larger number of proteins in the pathogenicity related protein families such as transcription factors, hydrolytic enzymes, and transmembrane transporters which play significant roles in pathogenicity, compared to non pathogenic species. In general, the disease is difficult to control, as physical, chemical and cultural methods of control are not only ineffective but also expensive.

The best method of control is breeding for resistant cultivars. Also, rhizosphere fungi such as *Trichoderma harzianum, T. asperellum, T. koningii, Penicillium* spp. and *Streptomyces griseoviridis* have been used to control the disease. This present review gives a general overview of some common *Fusarium* wilts.

Chapter 7 - The Wild rabbit (*Oryctolagus cuniculus*) and the Iberian lynx (*Lynx pardinus*) are endemic species of the Iberian Peninsula. The Iberian lynx is a specialist predator, listed as critically endangered, and rabbit represents the bulk of its diet as well as of many other Iberian predators. The decline of this emblematic predator has been recurrently explained by means of rabbit decline in Spain. A recent study has shown that wild rabbit

populations have declined a 55% in three decades in the country. Habitat destruction and fragmentation by infrastructures, the abandonment of marginal crops, the intensification of farmland ecosystems, and the direct and continuous persecution by farmers to preserve their crops, have been claimed as the main factors that account for this dramatic decline. In parallel, the impact of both myxoma virus and rabbit haemorrhagic disease (RHD) implied a relevant increase in rabbit mortality rates, while the species coped with a strong hunting pressure and an increase of competition with other wild herbivores. Nowadays, all these threats have not disappeared yet and conservation efforts have been very scarce. However, previous to rabbit decline, the area of distribution of the Iberian lynx had already suffered a reduction higher than 50%. This fact suggests that the extinction forces operating on Iberian lynx populations were other than rabbit population decline. The most probable hypothesis is that the main factors that accounted for this reduction were the direct persecution of the species and the massive non-selective predator control. Indeed, rabbit is abundant enough to maintain stable populations of Iberian lynx in many places, but the authorized predator control is usual and intensive preventing lynx establishment. In fact, Iberian lynx populations are now located in areas where predator control is not applied and rabbits are really scarce.

The Conservation National Plan for the Iberian Lynx has focused on introducing rabbits in these marginal areas favoring the increase of Iberian lynx productivity. Its time to add as one of the main objectives of the lynx recovery plans the removal of the causes of non-natural mortality to guarantee the survival of dispersing individuals and the success of future reintroductions. Despite the minor relevance of rabbit recovery to Iberian lynx conservation plans, author advocate for a National Plan for rabbit recovery to coordinate the actions that guarantees the conservation of wild rabbit populations in Spain, and thus to preserve also this endemic key species of the Mediterranean ecosystems.

Chapter 8 - Although extensive studies of the effects of heavy metals on marine invertebrates have well documented their bioaccumulation and toxicity, less is known about the genotoxicity of trace metals. The aim of this investigation was to assess the DNA damaging potential of cadmium in a benthic marine bivalve mollusc *Mizuhopecten yessoensis* collected from coastal waters. A comet assay (alkaline single-cell gel electrophoresis) was used to evaluate the degree of DNA damage in scallop gill cells induced by Cd accumulation. The results of the author's experimental studies indicated that Cd accumulation is followed by alterations in essential trace element homoeostasis (Fe, Zn) and DNA integrity (DNA strand breaks) in the gill cells. Based on the criteria for quantifying DNA strand breaks (the percentage of DNA in the comet tail, the length of the comet tail and the tail moment) used in the comet assay, Cd was found to be genotoxic to the scallop gill cells under laboratory exposure conditions. The possible mechanisms of Cd-induced DNA damage are discussed.

The author's results provide the first description of the use of the comet assay to detect DNA damage induced by Cd in an important pollution indicator organism *M. yessoensis*, which is common in coastal waters of the Sea of Japan. Thus, *M. yessoensis* can be used as an *in vivo* model for ecogenotoxicity assessment using the Comet assay.

Chapter 9 - This chapter highlights eco-physiological, breeding and agronomical research on the tropical starchy root crop cassava (*Manihot esculenta* Crantz) conducted at CIAT. The objectives were developing improved technologies needed to enhance productivity, root quality for human consumption and other uses, as well as conserving natural resources in different tropical/subtropical bio-systems where the crop is grown. Laboratory and field studies have elucidated several physiological/biochemical mechanisms and plant traits

underlying productivity in favorable conditions and tolerance to stressful environments such as prolonged water stress and marginal low-fertility soils. Cassava is endowed with inherent high photosynthetic capacity expressed in near optimal environments that correlates with biological productivity and storage root yield across environments and wide range of germplasm. Long leaf life, and hence better leaf retention, with reasonable photosynthetic rates was also associated with high yields, particularly in prolonged drought conditions. Extensive fine rooting systems capable of exploring deeper wet soils is another mechanism enhancing tolerance to water stress coupled with stomatal sensitivity to both atmospheric humidity and soil water shortages. Cassava leaves possess elevated activities of the C4 phosphoenolpyruvate carboxylase (PEPC) enzyme that correlate with photosynthesis and productivity in field-grown crops, indicating its importance as another selectable trait particularly for stressful environments. When cassava recovers from stress, it rapidly forms new leaves with higher photosynthetic capacity, which compensates for yield reductions from the previous prolonged stress. Selecting for medium-statured and short cassava instead of tall cassava is advantageous for saving on nutrient uptake and ensuring higher nutrient-use efficiency for root production without sacrificing potential yield. Germplasm from the core collection was screened for tolerance of soils low in P and K, resulting in the identification of several accessions with good levels of tolerance. In cooler zones such as higher altitudes in the tropics and lowland subtropics, cassava growth is slower and the crop stays in the ground for longer time to achieve adequate yields. Under these conditions, leaf formation is slower, leaf photosynthesis is much reduced, but leaf life is longer. Wide genetic variations exist for photosynthesis that may be valuable for selecting and breeding for genotypes that better tolerate cool climates. Combining enhanced leaf photosynthesis with the normally longer leaf life in cool climates may improve productivity. Results also point to the importance of field research versus greenhouse or growth-chamber studies that do not calibrate for representative environments to account for acclimation factors. Calibration becomes even more critical when data from indoor-grown plants are used to extrapolate to the field or to develop crop models. Basic research can be cost-effective, with high returns, even if slower. It can be especially successful when conducted in collaboration with multidisciplinary and/or multi-institutional teams that follow well-planned strategies and are focused towards fulfilling a set of high priority goals and objectives. Much remains to be done to further improve productivity while conserving dwindling natural resources such as water and land in view of the observed global climate changes. Developing countries, in particular, need more support to continue with maintenance research, which aims to upgrade previous findings and technologies; contribute to sustainable agricultural, economic, and social developments; and enhance food supply to meet increasing demands.

Chapter 10 - Climatic change has a major influence on various processes and components of watershed systems. Given that watershed systems provide critical services and products vital to sustainability of human and ecosystem needs, adaptation strategies become important to manage climatic impacts. There is a need for a framework to evaluate watershed-wide impacts of climatic stressors. Author develop a systems based approach to studying watershed impacts and propose a framework (WFCA) for watershed-based strategy for climatic adaptation. Literature on climatic impacts on watershed systems is relatively new and author use studies in specific aspects of hydrologic and ecosystem impacts to extend understanding to watershed scales. Author use a recent study in the U.S. as a basis for conceptualizing and evaluating adaptation strategies at a watershed scale, which will be discussed in the context of

world watersheds. Climatic impacts on water quantity (supplies, runoff) and water quality (sediment, nutrients) are discussed using a watershed system analysis involving the full hydrologic cycle. Specific impacts that are studied include fluxes in runoff, infiltration, evapotranspiration, runoff, surface impoundments, and water quality. Author propose that resilience of watershed systems can be improved through appropriate land cover and management practices that can handle climatic change impacts at local and regional scales. The strategies proposed include increase in forest cover, reduction of impervious cover, and implementation of BMPs that mitigate changes to watershed system. The approach offers a practical and effective approach that is vital to the sustainability of watershed systems under stress from climatic changes.

Chapter 11 - This work discusses the measurement of electrical properties of water and effluent as a tool for the optimization of water use during the purification process in biodiesel production. Water consumption and effluent generation from biofuels production, although frequently ignored, can have a significant environmental impact, particularly on community drinking water supply and sewage systems. The amount of water used in the purification process of biodiesel is large if recovery techniques are not adopted. In small -and medium-scale production plants, where for economic reasons is not feasible to use such techniques, the water to purified-FAME volume ratio can reach values in the range from 100% to 150%. Moreover, the effluent from the production process of biodiesel is mainly in the wash water, containing varying amount of alcohol and catalyst.

To achieve a sustainable biofuel production it is necessary to minimize the impact through proper plant design and control of the washing process during production. The results presented in this work show that the use of electrical techniques is a useful and economically viable contribution toward this goal.

Chapter 12 - In recognition of the continuous stress on the Earths' freshwater resources, the potable reuse of reclaimed wastewater has emerged to gaining widespread global acceptance as a sustainable alternative to traditional water supply. However, present wastewater treatment plants are not designed to treat the different array of complex and trace chemicals found in reclaimed wastewater that threaten consumers' health. Among the trace elements of greatest concern is lipo-polysaccharide (LPS) endotoxin. Associated with biological reactions, it is a constituent of the outer membrane of gram-negative bacteria and is uncontrollable at the source. Meanwhile, several studies have revealed that reclaimed wastewater toxicity has been linked to the existence of the LPS endotoxin in treated water. As such, gaining insight into the control and fate of endotoxin during wastewater reclamation a topic that poses serious challenges to water reuse experts is of great importance. The latest studies, which looked at different aspects of the fate and control of endotoxin during wastewater reclamation, filled in many of the knowledge gaps on the topic. The major goal of this chapter is to review the various issues and information associated with LPS endotoxin in reclaimed wastewater, their fate, control and removal during reclamation processes and evaluation of their potential threat to human health. Several aspects, including: i) previous investigations on endotoxin in environmental water and knowledge gaps, ii) Fate of endotoxin during biological reaction (activated sludge) and membrane bio-reactors (MBR), iii) Effect of return flow on the quality of effluent, iv) Characteristics of endotoxic indicative material, v) Effect of advanced treatment alternatives on endotoxin removal, and vi) Stress response due to exposure of Chinese hamster Ovary cells to reclaimed water, will be reviewed in this chapter.

Chapter 13 - Synthetic 4A and 5A zeolites were studied to explore the feasibility of applying these adsorbents for fluoride removal from drinking water. The zeolites were characterized with SEM/EDS and N_2-adsorption/desorption for their chemical and pore textural properties. The adsorption isotherms were correlated with the Langmuir and Freundlich adsorption equations. The fluoride adsorption isotherms on synthetic zeolite 4A and 5A followed the Freundlich model. The zeolite 5A adsorbent showed the highest fluoride adsorption capacity. It adsorbed up to 0.1 and 71 mg/g when the fluoride equilibrium concentration in water was 4.0 and 514 mg/L, respectively. Zeolite 5A adsorbed seven times more fluoride than zeolite 4A at the same initial concentration.

A pseudo-second order model and an intraparticle kinetic model fitted well the adsorption kinetic data for both synthetic zeolite adsorbents. It was found that both external and intraparticle diffusions contribute to the rate of removal of fluoride by the zeolites. From the experimental data obtained in this work, it was found that synthetic zeolite 5A has potential adsorption properties for fluoride removal from drinking water.

Chapter 14 - Root length density is a physiological character that has been associated with crop productivity in several crops. However, in mungbean the relationship between root length and yield had not been evaluated. In this study author explored the usefulness of root length density for yield improvement in mungbean. The correlation analysis of mungbean root length density with seed yield, as well as other physiological characters and yield components was conducted at Suranaree University of Technology (SUT) Farm, Nakhon Ratchasima, Thailand in 2008. Two F_6 populations (180-200 plants/population) were produced from two crosses between low and high root length density varieties/lines (KPS1 × V1415AG and CN60 ×V1414AG) via single-seed descent method. Twenty high seed yield plants and twenty low seed yield plants of each population were selected by visualization, and were characterized for physiological characters and yield components. It was found that seed yield per plant (seed weight per plant) was significantly correlated with root length density at 0-100 cm soil depth in both crosses (KPS1 × V1415AG, r= 0.894** and CN60 × V1414AG, r= 0.866**).In addition, correlation was also found between root length density and TDM in both low × high root length density crosses (KPS1 × V1415AG, r= 0.942** and CN60 ×V1414AG, r= 0.944**). These high root length density plants also tended to have higher number of pods per plant, pod length, number of seeds per pod, and number of seeds per plant than the ones with low root length density. By contrast, there was no correlation between 100 seed weight and harvest index (HI) with root length density. These results demonstrate that root length density can be efficiently used as a selection criterion for yield improvement in mungbean.

Chapter 15 - Carbon stabilization of tropical forest floor litter helps mitigate global warming, because it reduces an important source of CO_2 of the forest ecosystems. However, there is a lack of the C stabilization due to biological and physical effects such as low faunal activities, and segregation of floor litter layer and soil minerals by amid organic horizon, hindering organo-mineral complexation and humification. Thus, this chapter evaluates the C stabilization of tropical leaf litter, when microorganisms having different compositions and clay minerals were applied as inocula onto the litter. Litter associated fungi and bacteria separately, and their fungal-bacterial biofilms were applied with clay onto autoclaved litter, and incubated under laboratory conditions. Then, weight loss of the litter was measured, and they were analysed for organic matter fractions and organo-mineral complexation. The biofilms increased the weight loss, compared to the fungi or bacteria alone. Highest

humification was observed in fungal inoculation with clay. This suggests that the humification process can be improved by altering the microbial composition on the litter. It was found that the application of clay with any microbes is essential for the organo-mineral complexation. Here, author have manipulated microbial community to enhance the forest floor litter C storage in the soils. Therefore, this method can be proposed as a Clean Development Mechanism (CDM), which can be employed for carbon trading in tropics. Further studies are however needed to quantify the effect of this biotechnology under field conditions, and then to develop an inoculation technique to forest floor litter.

Chapter 16 - Fungal mats which can be artificially established to associate plants in the remediation of heavy-metal contaminated soil comprise primarily mycorrhizal, fairy-ring, and the extremely dense and long-lived coronar mycelia formed by wood-decay fungi around inoculated timber blocks. In mutualistic and antagonistic interactions with the autochthonous soil microflora, fungi are involved in weathering, uptake, and sorption of soil minerals during the degradation of organic residues. They alter availability and plant-uptake of (heavy) metals with the release of metal binding substances such as carboxylic acids, polysaccharides, proteins, and the solubilization of the dominating humic acid ligands. To determine the influence of saprobic soil fungi on leaching and plant-availability of macronutrients and heavy metals, Chinese cabbage was potted on metalliferous soil colonized by the coronar mycelia of *Hypholoma fasciculare* and *Kuehneromyces mutabilis.* Unplanted and non-inoculated treatments as well as sterilized soil samples inoculated with further soil fungi served as controls. Furthermore, in two open-air plots on non-contaminated soil (4 m^2 each) interactions of *H. fasciculare* with turf grasses, and of *K. mutabilis* mycelia with the dominating buttercup vegetation were studied. Under sterile conditions, all test fungi but *Scytalidium lignicola* acidified autoclaved metalliferous soil. Mitosporers depleted NH_4^+ and NO_3^- whereas basidiomycetes accumulated NH_4^+ (1.5-3 times) apparently from the soil's N_{org} stock and did not compete for the plant's NO_3^- resources. Fungi known for low carboxylic-acid production on a poor suspended-soil medium increased the solubility of humic substance (HS) together with all of its associated polyvalent metals but Ca moderately by factors 1.3 to 2.2. *Aspergillus niger* and *Fomitopsis pinicola* reached solubilization factors of 2.7/3.1 in the case of HS, and of 7 to 54 in the case of the elements, As, Co, Cu, Fe, Mn, Ni, U, and Zn by chelation with fungal citric and oxalic acids. Calcium precipitated as insoluble oxalate. The fungi reduced the molecular size of humic colloids mainly by the action of carboxylic acids but hardly by laccases, and increased thus their mobility in the mass flow. Nevertheless, the number of dissolved cations per gram of dissolved HS as their main potential ligand remained low in all treatments, inviting them to form the less plant-available metal-humic complexes.

Of both coronar mycelia in nonsterile potted soil, only that of *H. fasciculare* could partly compensate for consume of NH_4^+ and NO_3^- by Chinese cabbage. It was however due to the release of fungal toxicants such as fasciculol D that in combination with *H. fasciculare* and *K. mutabilis* mycelia, shoot biomass (by 33/ 23 %) and N_{org} content (by 9/32 %) were reduced. In the absence of strong (heavy) metal chelants in soil, the value of shoot N_{org} determines the concentrations of the transition metals, (Cd), Co, Cu, Mn, Ni, and Zn but Fe which are taken up to constitute the plant's metalloproteins. Fixing the conditions in control plants at 100 %, shoot concentrations in the sum of Cu, Mn, Ni, and Zn in *H. fasciculare/K. mutabilis* associated plants exceeded the level suiting the N_{org} content with 49/87 %. Considering the lower biomass in relation to plants from non-inoculated soil, shoots contained 91/97 % of the four transition metals in absolute amounts. In field plots, both coronar *H. fasciculare* and *K.*

mutabilis mycelia increased soil NH_4^+ resources to 300 %. Shoots of the growth-inhibited turf grasses lost 26 % in N_{org} but reached 60 % more in the sum of Co, Cu, Mn, Ni, and Zn than the level of N_{org} made one expect. Buttercup was tolerant of *K.-mutabilis* inhibitors. Its shoots contained 30 % more in N_{org}, and 58 % more in the sum of the transition metals than control plants.

It is concluded that the surplus in uptake of transition metals goes back to the action of strong chelants in the soil solution of which carboxylic acids, amino acids such as cysteine, and/or non-identified fungal ligands must be taken into account. Basidiomycetes can thus contribute to phytoextraction. Its efficacy was nevertheless impaired by fungal inhibitors of plant growth and N_{org} formation. Combinations of ground fungi of higher ammonifying and soil acidifying potential with plant species tolerant of fungal inhibitors will thus be tested in further investigations. Solubilization of metal-humic complexes by the combined action of plants and fungi increases the potential leaching rate in potted Settendorf soil by 50 %. This fact is evidence enough that non-symbiotic ground fungi, apart from precipitations of Ca by oxalate, improve plant access to nitrogen and to a surplus in HS- and carboxylate-coordinated elements of moderate stability and plant availability. Moreover, unlike the conditions in mycorrhizal associations, fungal blockage of heavy-metal uptake by the plant is not postulated, and mineral nutrient sequestration at plant expense could not be shown.

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