REPORT

MEETING of COST 869

Mitigation options for nutrient reduction in surface water and groundwaters

Working Group 2 and 3

14-16 June 2010

Location: MTT Agrifood Research Finland, Jokioinen, Finland

Topic of the meeting:

Novel methods for reducing agricultural nutrient loading and eutrophication

Local organizer

Eila Turtola

Co-organizers

Petri Ekholm & Wim Chardon

Report edited by Wim Chardon

AGENDA

Sunday, June 13
Arrival at Forssa (10 km from MTT Agrifood Research Finland), Hotel Pumpulienkeli
Address of the hotel: Hämeentie 7, Torikeskus, 30100 Forssa
19 - 21 Welcome at the hotel bar

Monday, June 14
9.30 Registration at MTT. Address: Humppilantie 9, 31600 Jokioinen

10.15 Erkki Kemppainen, Finland: Opening of the workshop

10.30 **Session 1**: *Novel methods - innovations, experiences, prospects*
George A. O'Connor, USA: Amendments to control P mobility [KEYNOTE]
Deborah Ballantine, New Zealand: Methods for reducing agricultural nutrient loading and eutrophication: The New Zealand story [KEYNOTE]

14.00 **Session 2**: *Potential of phosphorus and nitrogen binding materials*
Wim Chardon, The Netherlands: Testing phosphorus sorbing materials **-** results and questions about criteria
Risto Uusitalo, Finland: Phosphate retention/solubilization characteristics of industrially produced Ca-Fe oxide granules
Olav Eklund, Finland: Nanostructured vermiculite **-** A new material for recycling ammonium from different types of polluted matters

15.15 Coffee + **poster session**

16.30 Excursion at MTT to sites with new measures

18.30 Evening and dinner at Elonkierto park with optional canoeing and sauna by the River Loimijoki

Tuesday, June 15

9.00 **Session 3**: *Practical results for runoff, buffer zones and wetlands with new measures*
Raymond Bernard Brennan, Rep. of Ireland: Evaluation of chemical amendments to control soluble phosphorus losses from dairy cattle slurry
Jaana Uusi-Kämppä, Finland: A rainfall simulation study on P removal in buffer zones amended with Fe and Ca compounds
Barbro Ulén, Sweden: Structure liming and omitting ploughing as measures to reduce agricultural nutrient loading to surface waters
Anne Falk Øgaard, Norway: Phosphate adsorption on different filter materials

11.00 **Session 3 continues**
Pia Kynkäänniemi, Sweden: Constructed wetland to mitigate P losses from hotspots in agricultural areas
Anne-Mari Ventelä, Finland: Winter time nutrient load is challenging long-term water protection measures - urgent need for new tools
Clare Deasy, United Kingdom: Assessing the potential for using constructed wetlands as mitigation options for phosphorus and sediment within UK agriculture
Petri Ekholm, Finland: Does gypsum reduce phosphorus losses in an agricultural catchment?

12.30 Lunch + **poster session**

14.00 Excursion to a wetland site near Turku, and the Archipelago Sea

Wednesday, June 16

9.00 Session 4: *More about catchments: measures on critical source areas*
Daniel Fiala, Czech Republik: Shortfall of P budget in Orlik Reservoir - statistical tryout among culprints with sparse data
Micha Gebel**,** Germany: Evaluation of critical source areas to reduce nutrient loading from agriculture in river basins in Saxony/Germany
Jaroslav Antal, Slovakia: Reduction of groundwater pollution by nitrate-nitrogen with agrotechnical measures
Jeroen de Klein, The Netherlands: Balancing emission reduction measures and ecological water quality benefits; the river Dommel case

11.00 Session 5: *Remedies in water bodies*
Jouni Lehtoranta, Finland: What to do with extra electrons - how combating eutrophication may affect mineralization pathways
Guido Waajen, The Netherlands: Application of lanthanum-modified bentonite and flocculent reduces eutrophication in a lake
Bryan Spears, United Kingdom: Using Phoslock®, to control cyanobacteria in a shallow eutrophic Scottish reservoir - ecological responses across multiple trophic levels
Sebastian Meis, United Kingdom: Using Phoslock® to control cyanobacteria in a shallow eutrophic Scottish reservoir - assessing its impact on sediment phosphorus pools

Poster presentations:

Borda, T., Celi, L., Buenemann, E., Oberson, A., Frossard, E., Barberis, E.: Release of P from soil and suspended solids to assess the real risk of eutrophication
De Bolle, S., Gebremikael, M.T., De Neve, S.: Can phosphate solubilising bacteria be of use on phosphate saturated soils?
Hämäläinen, J.-M., Kulokoski, U., Pietola, L.: Gypsum effects on soil characteristics and phosphorus sorption
Johannesson, K.M., Tonderski, K., Wedding, B., Weisner, S.E.B.: Phosphorus dynamics and retention in non-point source wetlands in southern Sweden
Kjaergaard, C.: Sustainable phosphorus remediation and recycling technologies in the landscape
Koski-Vähälä, J., Saarijärvi, E., Heikkilä, J.: Modelling of the effects of phosphorus load in Iisalmi Route
Lilja, H.: Erosion mapping with Light Detection and Ranging (LIDAR) and RUSLE - method testing at experimental plots and farmers' fields
Martin, M., Hossain, J., Simona, S., Celi, L., Borda, T., Barberis, E.: Potential phosphorus and arsenic release in dispersed particulate form from Bangladesh rice fields
Närvänen, A., Uusitalo, R.: Reduction of phosphorus load from critical source areas using ferric sulphate
Pietola, L., Kulokoski, U.: Gypsum effects on percolated water characteristics at various soil P status
Purnavel, G., Dana, D., Filiche, E., Petrovici, G., Dodocioiu, A.M., Mocanu, R., Cotet, V.: Protection of hill lakes through erosion control works
Saarijärvi, K., Virkajärvi, P.: Surface runoff simulator (SIMU) hastens the research on phosphorus losses from grasslands
Skowron, P.: Acidification as a controlling factor for the content of an active form of nutrients in soil
Stoicheva, D., Kercheva, M., Koleva, V., Simeonova, T.: Agricultural practice and nitrogen leaching at the field experiment: Risk analyses using NLEAP model
Uusitalo, R., Ylivainio, K., Nylund, P., Pietola, L., Turtola, E.: Rainfall simulations of Jokioinen clay soils amended with gypsum to decrease soil losses and associated P transfer
Vakkilainen, P., Alakukku, L., Myllys, M., Nurminen, J., Paasonen-Kivekäs, M., Puustinen, M., Peltomaa, R., Äijö, H.: Nutrient transport from different kind of subsurface drainage systems on clay soil
Tonderski, K., Pers, C., Arheimer, B.: Assessing the effect of constructed wetlands on non-point source nitrogen removal.
Valkama, P., Lahti, K., Särkelä, A.: Applying on-line monitoring for quantification of diffuse load

Participants

Sara De Bolle	Belgium	Katri Rankinen	Finland
Dimitranka Stoicheva	Bulgaria	Micha Gebel	Germany
Daniel Fiala	Czech Rep.	Raymond Brennan	Ireland
Charlotte Kjaergaard	Denmark	Maria Martin	Italy
Anne-Mari Ventelä	Finland	Luisella Celi	Italy
Olav Eklund	Finland	Wim Chardon	Netherlands
Jouni Lehtoranta	Finland	Guido Waajen	Netherlands
Risto Uusitalo	Finland	Jeroen De Klein	Netherlands
Eila Turtola	Finland	Deborah Ballantine	New Zealand
Aaro Närvänen	Finland	Anne Falk Øgaard	Norway
Jaana Uusi-Kämppä	Finland	Anne-Grete Blankenberg	Norway
Liisa Pietola	Finland	Tore Krogstad	Norway
Juho-Matti Hämäläinen	Finland	Piotr Skowron	Poland
Pasi Valkama	Finland	Daniela Dana	Romania
Kirsi Saarijärvi	Finland	Romulus Mocanu	Romania
Maija Paasonen-Kivekäs	Finland	Jaroslav Antal	Slovakia
Petri Ekholm	Finland	Barbro Ulén	Sweden
Harri Lilja	Finland	Pia Kynkäänniemi	Sweden
Tommi Peltovuori	Finland	Karin Johannesson	Sweden
Riku Lehtonen	Finland	Karin Tonderski	Sweden
Olli Konstari	Finland	Pierre Julien	Switzerland
Erkki Saarijärvi	Finland	Clare Deasy	UK
Helena Soinne	Finland	Bryan Spears	UK
Kimmo Rasa	Finland	Sebastian Meis	UK
Jari Hyväluoma	Finland	George O'Connor	USA
Aleksander Klimeski	Finland		

General, excursions

The meeting was attended by 51 persons from 18 countries. During the meeting there were 21 oral contributions of which 2 invited (O'Connor from the USA, and Ballantine from New Zealand), and 18 posters were presented. During excursions experimental sites were visited where runoff is studied and edge-of-field reactive permeable barriers will be tested; an apparatus that doses $Fe_2(SO_4)_3$ to stream water for P removal (Närvänen et al., 2008; see also his poster); a filter system that treats wetland effluent with Sachtofer PR granules (a Ca-Fe compound), and a facility where lake influent is treated with liquid polyaluminiumchloride in order to flocculate soil particles and associated P, and precipitate ortho-P. After dosing, the water is led via sedimentation ponds. A description of the objects visited during the excursion can be found here.

Summary of presentations

Session 1: *Novel methods - innovations, experiences, prospects*

George O'Connor (USA) gave a summary of work done during in- and outside the USA on capturing P, augmenting the effect of Nutrient Management Plans. Both metal salts like alum [$Al_2(SO_4)_3$] or $AL(OH)_3$, and Water Treatment Residuals (WTR) have been studied extensively during the last 15 years, in incubation and column studies, lakes, storm water retention basins, constructed wetlands, buffer strips. The chemicals can also be added to manure and sewage sludge, reducing P mobility after application. A summary of work done on this topic in Florida can be found in a recent report (Wanielista et al., 2009), and on WTR in Ippolito et al. (2011). The advantage of WTR is that it contains less salts and contaminants than other wastes like e.g. fly ash and bauxite red mud, that are suggested for this purpose. Evidence was found for adsorption of P in solid micropores, so no precipitation or surface adsorption. Complexes formed have a long-term stability. Recent work focused on WTR application rate, based on P saturation of the soil and the oxalate extractable Al and Fe content of the WTR. In the near future vertical barriers with WTR along waterways will be tested.

Deborah Ballantine (New Zealand) gave an overview of research in her country on trapping P, partly based on a recent review paper (Ballantine & Tanner, 2010). Water quality in New Zealand is declining, particularly in lowland streams and rivers; this is mainly due to pastoral agriculture, where sheep and beef production were converted to intensive dairy. In the past, only wetlands were tested for P removal from subsurface drainage water, but their capacity is limited. They are good for NO_3-N removal They can even become a source of P on the long term, especially when they were installed on former agricultural land without removing the top soil before. Research was done on increasing wetland P removal, by adding materials found or produced in NZ: (i) naturally occurring products e.g. allophane, tephra; (ii) Processed and modified materials, e.g. modified zeolites, alum, Phoslock™; (iii) Waste materials e.g. iron slag and boiler ash. When alum was used for preventing P loss via runoff this appeared not to be effective, probably because the alum was washed away with rainfall. Iron and melter slags were tested in waste water treatment filters, as backfill on top of tile drains, in 'socks' in the outlet of drains and on the bottom of streams.

Session 2: *Potential of phosphorus and nitrogen binding materials*

Wim Chardon tested two materials that are by-products formed during the production of drinking water from anaerobic groundwater. The Fe^{2+} in the raw water is oxidized to $Fe(OH)_3$, either as a sludge or as a coating on sand. Sludge is a fine material that has a low hydraulic conductivity. When applied in a filter this may cause preferential flow, as was also found during testing of the Sachtofer filter (see General, excursions). During sorption studies a very steep isotherm was found, the so-called high affinity type. In a column study iron coated sand retained most P per unit volume, due to its high Fe content. During a desorption experiment it was found that ca. 70% of the P sorbed to sludge was bound strongly.

Risto Uusitalo studied retention and solubilization characteristics of industrially produced granules containing calcium (Ca) and iron (Fe). the granules showed a very fast sorption, especially by smaller (< 2 mm) grains. Both precipitation as secondary Ca-phosphates like hydroxyapatite, and sorption to Ca-associations or Fe hydroxides are possible mechanisms for binding. the granules were effective in retaining P leached from clay and peat soils in columns. When P-saturated granules were immersed in lake water, they lost > 80% of its Ca, but only 25% of the P bound. Apparently the Fe hydroxides had captured the P released from the Ca compounds. A decrease was found in P binding by the granules when the temperature was decreased from 21 to 7 ℃.

Olav Eklund presented a patented technology that involves modifications applied to the crystalline lattice of the natural mineral vermiculite. This can be used to capture NH_4-N, fast and selective, from polluted water, soil, and gas. It can be re-used as a slow release N-fertilizer and soil-conditioner. It has a business potential in the dry toilet market, agriculture, waste water treatment, landfill, composting processes, and slaughterhouses.

Session 3: <u>Practical results for runoff, buffer zones and wetlands with new measures</u>

Raymond Brennan examined at laboratory scale the effect of chemical amendments on dissolved reactive phosphorus (DRP) and total phosphorus (TP) loss from grassland following land spreading of dairy cattle slurry. The amendments tested in a runoff study using rainfall simulation were alum ($Al_2(SO_4)_3$ and burnt lime. Suspended sediment loss, P fractions and metals in runoff were determined. Alum reduced TP loss with 93% and DRP loss with 83%, for lime this was 82 and 69%, respectively. A disadvantage of adding chemicals like alum or lime is that they are expensive. Waste materials are cheaper but their effectiveness is probably lower, and side-effects still have to be studied.

Jaana Uusi-Kämppä treated undisturbed surface soil columns from vegetated buffer zones with either gypsum, Fe-gypsum, ground $CaCO_3$ or granulated $Fe_2(SO_4)_3$. The aim was to reduce DRP loss in spring which can be high, especially after freeze-thaw events. Simulated rainfall on the columns induced surface runoff, and DRP and PP loss were determined. The DRP and TP concentrations decreased in the order: control ≈ gypsum ≈ $CaCO_3$ >> $Fe_2(SO_4)_3$ ≈ Fe-gypsum. Thus, only Fe was capable of reducing P loss, and Ca was not.

Barbro Ulén tested the influence of structure liming with burnt lime (CaO) on loss of particulate P. This causes an immediate reaction with clay, that increases aggregate stability. Due to liming, TP leaching declined significantly from 0.22 to 0.085 kg t^{-1} year^{-1} (related to harvested amount of barley). Omitting ploughing and only cultivating in autumn did not decrease TP losses, but reduced NO_3-losses in the second year (see also Ulén et al., 2010).

Anne Falk Øgaard studied adsorption of P to different materials that could be of interest for use as filters in constructed wetlands: Maxit Filtralite P, Kemira CFH-12 ($Fe(OH)_3$-granules), Fe-Ca-granules, crushed lime stone and coral sand. In a batch experiment, the $Fe(OH)_3$- and Fe-Ca-granules were most effective for P sorption after 6 hr, lime stone was least effective. Leading tie drain water through a bed with Filtralite P led to a reduction with 57 % of total P.

Pia Kynkäänniemi studied a constructed wetland, aimed at purifying drainage water from a horse paddock. It consists of a 1 m deep sedimentation basin and 2 shallow (0.3 m) vegetation filters. Sedimentation measurements using plates and traps show that particle retention mainly occurred close to the inlet, in the sedimentation basin and the first vegetation filter. Retention was not very effective (9% for TP, 5% DP, and 13% for PP), probably caused by the fact that vegetation was not developed yet.

Anne-Mari Ventelä studied Lake Pyhäjärvi, where since 1995, nearly all farmers in the catchment have committed to the Finnish Agri-environmental program to implement basic water protection measures. This includes buffer zones, sedimentation ponds, and wetlands; new options are tested: a lime/sand ditch filter along a river, filter fields, and ditch bottom filters. Especially peaks in concentrations were cut of effectively. Beside lime/sand, Fosfilt, a powder ferrous by-product of TiO_2 production was used, but problems with filter blocking occurred. During recent years the load of P from the catchment during winter time has increased, and new innovative methods are needed.

Clare Deasy investigates edge-of-field mitigation approaches, which can tackle both surface and subsurface pathways where they discharge into ditches and streams. Focus is on constructed wetlands, the functioning and effectiveness is being tested on sediment and nutrient accumulation through continuous monitoring of discharge and turbidity. Pollution swapping (creating other environmental problems like CO_2, N_2O, CH_4 emission during N/P removal) will be an important topic. Initial indications suggest some sites may be sediment sources to stream in first year after construction, while at other sites deposition of sediment is evident. Wetland effectiveness is expected to increase as wetlands mature.

Petri Ekholm studies possibilities to reduce P losses from agricultural catchments using gypsum, either as soil amendment or as amendment to liquid manure aimed to precipitating P. In-stream turbidity and particulate P were strongly (ca. 60 %) reduced after gypsum application. Sulphate leaching could create problems when it is converted into S^{2-} in an anaerobic environment, since it can release P bound to Fe(III) via formation of FeS.

Session 4: <u>*More about catchments: measures on critical source areas*</u>

Daniel Fiala works on P sources apportionment and the impact of different sources on summer algal growth. Main topic is the influence of uncertainties in collected data, like sampling frequency. At he moment 75% of the P input to a reservoir has an unknown origin. Erosion and widespread fishponds are now most suspected sources of uncertainty. It is aimed to resolve the fate of P during the transport phase, like overflow and erosion mixing, or sedimentation.

Mischa Gebel modeled sediment and nutrient (N, P) input in water bodies of the Federal State of Saxony (Germany) using the simulation tool „Stoffbilanz". Sediment and particle bound P inputs are calculated using the concept of "area connectivity". GIS functions are used to delineate areas with high hydraulic connectivity to the river network. The likelihood of connectivity is computed, considering the distance to the watercourse, transport capacity of surface runoff and sedimentation of soil in the landscape. The model is frequently used for scenario analysis, e.g. for studying the influence of introducing energy crops on N/P leaching.

Jaroslav Antal studies NO_3 leaching as influenced by two different crop rotations, biological and cereal, two different fertilization variants, manure, straw and NPK fertilization, and two different ways of soil cultivation: conventional and protective. The influence on NO_3-leaching decreased in the order: crop rotation > soil cultivation > fertilization.

Jeroen de Klein works on a two-year project to link ecological water quality to specific regional pressures by intensive monitoring and modeling. The main idea is to shift from emission reduction targets (as an objective itself) to vulnerability and resilience of the aquatic ecosystem. It appears to be difficult to link ecology with catchment management. Important measures will be increasing WWTP capacity and optimizing the sewerage system in order to reduce overflow which creates untreated sewage water losses to the stream. The project may lead to a large reduction in investment costs..

Session 5: <u>*Remedies in water bodies*</u>

Deborah Ballantine referred to an experiment in which alum, Phoslock™, Aqual-P™ (zeolite treated with aluminum salt), and allophane were tested for capping sediment to prevent release of both P and NH_4^+. For this purpose, Aqual-P™ functioned best. Phoslock™ is a lanthanum (La) amended bentonite clay, a stable product over a wide range of pH, designed to adsorb and bind P permanently, also under anaerobic conditions. However, it is expensive and thus mainly suitable for waters used for tourism. Also, some doubt exists if release of La occurs from treated sediment and if this could have a detrimental effect. A problem with studying La release is that there is no analytical method available to separate dissolved La from La bound to dispersed colloidal particles.

Guido Waaijen described treatment of a lake suffering from frequent cyanobacteria blooms with a combination of $FeCl_3$ + $Ca(OH)_2$ and Phoslock. Within a few days after the application the existing cyanobacterial bloom disappeared, the transparency increased and the concentration of P decreased. After the treatment, an indication of La release from the sediment was found, this will be studied in more detail.

Bryan Spears and *Sebastian Meis* described Phoslock addition to a shallow isolated reservoir, used for recreation. Also in this study some La was found in the water column during 4 months after application. The response of macrophytes (responded positively with water clarity), macroinvertrebrates (mixed response), and zooplankton (driven by the phytoplankton) was followed during one year after application. Release of P from the sediment was correlated to wind direction, this was ascribed to mixing of the sediment by wind. The mechanism of Phoslock was studied by following the distribution of P over different pools in the top layer of the sediment. Also, the variability in the horizontal and vertical distribution of La within the reservoir was studied. Bio-turbation and macrophytes influenced the vertical distribution, and wind-induced sediment resuspension the horizontal distribution. Dilution by the Phoslock clay caused a decrease in concentration of the reductant soluble P pool. Phoslock La did not seem to compete with existing pools, but to bind P when it is released from a any given pool.

Jouni Lehtoranta discussed the role of oxygen, nitrate, manganese and iron oxides and sulphate as external electron acceptors that are released during mineralization of organic matter. Under anaerobic conditions this may lead to release of soluble or gaseous NH_4, Mn(II), Fe(II), H_2S and CH_4**.** Iron(III) in hydroxides can be reduced to Fe(II) by H_2S followed by precipitation of FeS or FeS_2, which can lead to release of P bound to the hydroxides. Reducing erosion can lead to a smaller input in surface water of hydroxides as electron acceptors, and an increasing risk of P release by FeS formation.

Poster Session

Theresa Borda studied bulk soil and dispersible soil material on NPK, PK, slurry and manure plots. Manured plots had the smallest amount of dispersible soil particles due to the high soil C content, but the particles from manured plots were most enriched with P, and had the highest bioavailability.

Daniela Dana presented the effectiveness of many measures taken for reducing soil erosion: increased percentage straw cereals / less cultivator plants; contour, split and strip farming; banquet terraces, and an erosion control works

Sara De Bolle did a literature and laboratory research on bacteria that can solubilize phosphorus in P deficient situations. The question is if they also have the ability to solubilize P in soil with an abundant amount of P. The aim is to improve uptake of P by plants in P saturated soils, so the environmental risk. First tests showed promising results.

Juho-Matti Hämäläinen studied the influence of varying phosphogypsum additions to a clay soil on the adsorption characteristics. An addition of 5 g per L soil was most effective in stimulating P adsorption; higher rates wee less effective due to the water soluble P content of the gypsum.

Karin Johannesson studies phosphorus dynamics and retention in 7 non-point source wetlands. Retention in the wetland of phosphorus from agricultural catchments is measured, and the dynamics of inflow and outflow P concentrations is investigated. High concentrations of P occurred during low flow periods. All wetlands retained P, but two wetlands released P in specific years.

Charlotte Kjaergaard presented a new project entitled: Sustainable phosphorus remediation and recycling technologies in the landscape (SuppremeTech). Research will be done both on P and N removal via filter technologies, filter substrates, constructed wetlands, cost-effectiveness, contamination risk and filter function regarding pollutants.

Jukka Koski-Vähälä works on modelling of the effects of phosphorus load in Iisalmi Route, a chain of lakes. After creation the model was calibrated and tested, which showed that the model is reliable. Results indicated that model works better with lakes that have a lower level of eutrophication.

Harri Lilja studies erosion risk mapping with Light Detection and Ranging (LIDAR) and the RUSLE – method, and showed testing at experimental plots and farmers' fields. The model was adapted for changes caused by cultivation measures and rainfall.

Maria Martin works on potential phosphorus and arsenic release in dispersed particulate form from Bangladesh rice fields. Arsenate enters the fields via irrigation with groundwater that is often polluted with As and P, fertilizers are the main P source. During the monsoon season soils can loose much As and P via loss of soil particles.

Aaro Närvänen presented equipment that is able to doze ferric sulphate into passing surface water based on water level. It is useful for locations where (very) high concentrations of ortho-P are found, e.g. near exercise areas and milking stations [see also reference with link below].

Pertti Vakkilainen presented results of field work on the nutrient load in two subsurface drainage systems on clay soil. In method I gravel is used as an envelope and the drain spacing is 8 m. In the method II a very thin textile (<1 mm) is used as an envelope and the drain spacing is 6 m. First results show that total N concentrations and load increased in the new systems compared to control.

Liisa Pietola studied effects of gypsum on percolated water characteristics on soils with various P status. Gypsum decreased loss of dissolved reactive P; the relative effect was largest at a low soil P status. Turbidity of leachate was strongly decreased, but EC increased by gypsum.

Kirsi Saarijärvi described (intended) research on P load on 3 different scales: miniplot (0.4 m^2), field (400 m^2) and catchment 3 km^2). On miniplots a Surface Runoff Simulator was used to study the influence of adding chemicals on P loss via runoff due to melting snow. Chemicals included granulated or dissolved $Fe_2(SO_4)_3$, $Fe(SO_4)$*$7H_2O$, and $Al_2(SO_4)_3$, and Phoslock® and Biotite. Preliminary results indicate that Fe-based chemicals are effective in reducing total and dissolved P losses, but that Phoslock®, and Biotite increased losses.

Piotr Skowron studied the influence of pH (3.5 - 7.5) on the active forms of N (NH_4 or NO_3), ortho-P, K^+, Ca^{2+}, Mg^{2+} and Zn^{2+} in 1:10 water extracts from 4 incubated soils. Increasing pH decreased extracted cations (NH_4, K^+, Ca^{2+}, Mg^{2+} and Zn^{2+}), but increased NO_3, and ortho-P above pH 4.

Dimitranka Stoicheva did a risk analyses on NO3 leaching to groundwater using the NLEAP model. Data from 2 long-term (resp. 15 yr vegetable rotation and 38 yr continuous maize) field experiments were used for this exercise.

Karin Tonderski studied the effect of constructed wetlands on non-point source N and P removal . A scenario analysis was done on the effect on the N and P load to the sea of an additional 6000 ha wetlands if created in areas with high losses of N and P from agriculture. Uncertainties associated with model assumptions and process descriptions were an important topic. Observed removal rate constants lead to a large uncertainty in model predictions.

Risto Uusitalo did rainfall simulations of Jokioinen clay soils amended with lime or gypsum, in order to decrease soil dispersion and losses and associated P transfer. Samples taken 19 months after application had a much higher amount of suspended particles than samples taken after 7 months; effect of time on P loss was not known yet.

Pasi Valkama presented application of on-line monitoring on quantification of diffuse load with N and P. Automated monitoring stations measured turbidity, NO_3 concentration, conductivity, water temperature and water level in every 30 to 60 minutes. Turbidity data were calibrated to total P, particulate P and suspended solids (SS) concentrations by using regression analysis. With high resolution on-line data collected from agricultural watersheds it is possible to reliably estimate the total load and to detect even the minor changes in water quality. It is possible to investigate the influence of certain agricultural practices applied in the catchment. The method has been used successfully to investigate the effects of gypsum amendment on P fluxes and erosion.

References

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