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Global TraPs

Transdisciplinary stakeholder approach to sustainable phosphorus management

The third workshop of the Global TraPs project, Zurich, 29-30th August 2011, brought together researchers, industry, international organisations and NGOs to explore how humans can more sustainably manage phosphorus (P) worldwide.

N and P fertilisers

Nutrient supply and food security

Without nutrient input in fertilisers, the world's population could not be fed. What are the implications for society's management of N and P?

Resources and consumption

Phosphorus balance for Europe

Assessment of P-flows, sinks and balances, covering soil and agriculture, consumption, tradable materials and losses to the environment

Finite resource

Rethinking the options for phosphorus

An assessment of the phosphorus life cycle and options for conserving a finite resource

Switzerland

P-flows, recycling and social issues

The authors calculate a phosphorus flow balance for Switzerland, assess the significance of phosphorus in animal carcass wastes and consider the social trade-off between P-recycling and health protection.

P and people

Phosphorus and planetary boundary conditions

A macro-model looks at long-term links between phosphate resources and use, market control, human population and possible societal outcomes in terms of global stability.

Water management

EU water policy

Sewage and water legislation review

A "fitness check" of EU water policy for the Commission concludes that the Urban Waste Water Treatment and Water Framework Directives are effective, with questions on implementation, but emphasises the need to improve consistency with agriculture, urbanisation and energy legislations.

Wastewater reuse

Fertilising eggplant and tomato crops

Nutrient recycling and contamination risk of wastewater crop application in semi-arid West Africa.

Recycling sewage nutrients

Apartment-scale wastewater crop fertilisation

Very small scale use of ozone-treated wastewater to fertilise vegetable crops shows feasibility and safety

Conferences and publications

Phosphates 2012

Phosphate industry conference

Major 2-yearly conference for the worldwide phosphate industry (rock production, fertiliser, animal feeds, food, detergents, other industrial uses). El-Jadida, Morocco, 19th - 21st March 2012:

<http://www.crugroup.com/events/phosphates/>

Toulouse, France

Recycling and reuse of phosphates

Phosphate recycling, P-recovery processes, phosphate precipitation, uses of recovered phosphate products. 23rd November 2011, Toulouse, France. In French

<https://phosphor.cemagref.fr/events/FlyerP.pdf>

The Phosphorus cycle

Chemosphere special issue

Chemosphere journal (Elsevier publishers) special issue on "The Phosphorus Cycle": Volume 84, Issue 6, Pages 735-854 (August 2011).

<http://www.sciencedirect.com/science/journal/00456535/84/6>

Nutrient resources

Global TraPs

Transdisciplinary stakeholder approach to sustainable phosphorus management

Global TraPs is a 5 year (2010-2015) worldwide transdisciplinary project led by Switzerland's leading university of technology (ETH Zurich), with involvement of industry and stakeholders, which aims to examine the whole phosphorus cycle and develop proposals for consideration of decision makers, particularly for phosphate stewardship in agriculture

Questions addressed include exploration, mining, processing, use, recycling, environmental dissemination, plus cross-cutting issues such as trade and finance. Through case studies and stakeholder dialogue, global issues of phosphate stewardship and management, will be assessed, and proposals developed concerning including resource availability, more efficient use, avoiding wastes and losses, and phosphorus recovery and recycling.

The project was developed in 2010 and launched in early 2011, and the **third workshop** in Zurich at the end of August 2011 showed the interest of different stakeholder groups, with **participation of some 70 persons from Europe, Japan, North America, South Africa, Australia, as well as international organisations.**

Science and practice

The project brings together 'science' participants (researchers in stakeholder and societal processes, phosphorus cycles, agriculture, waste minimisation, P-recycling ...) and 'practice' participants from industry, NGOs and international and development organisations.

Active stakeholders include the fertiliser industry, detergent phosphate industry and phosphate mining and exploration industries, and international organisations including IFDC (International Fertilizer Development Center), FAO (UN Food and Agriculture Organisation), International Plant Nutrition Institute (IPNI), United Nations Environment Programme (UNEP).

Phosphorus is one of the key nutrients necessary to human, animal and plant life. Phosphorus is also a

finite resource that must be used more effectively and efficiently. By focusing on phosphorus from the supply chain perspective, the Global TraPs initiative seeks to bring greater understanding to a number of issues that confront humanity and our environment. Sustainable management of P is a key to ensuring food security and improving environmental quality.

Through case studies, Global TraPs work groups will investigate, for example, how to prevent P from organic and inorganic fertilizers used on farms from running off into waterways, where it can drastically degrade living conditions for aquatic life.

Another focus, reusing P from waste streams such as sewage sludge, can be important to sustainable phosphorus use.

Transdisciplinary approach

Global TraPs stands for "**Global Transdisciplinary Processes for Sustainable Phosphorus Management.**" The five-year project (2010-2015) follows a transdisciplinary approach, a process designed to integrate perspectives from participants who represent diverse parts of society and generate knowledge to benefit mankind.

Another feature of this approach is that it allows for discourse, reflection and learning in a **non-politicized and non-competitive arena** that allows participants to identify options for more sustainable use of phosphorus.

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IFDC (a public international organization focused on increasing and sustaining food security and agricultural productivity in developing countries) www.ifdc.org

Global TraPs: <http://www.uns.ethz.ch/gt>

N and P fertilisers

Nutrient supply and food security

Global population growth since the mid nineteenth century has been made possible by the supply of nitrogen (N), phosphorus (P) and thus also energy in mineral fertilisers. Without nitrogen fertilisers, only 50-60% of the world's current population could be fed from existing cropland. Without phosphate fertilisers, the population of

industrialised Europe was already becoming unsustainable by the early nineteenth century.

The authors participated in previous papers (see after) assessing phosphorus flows in Europe (2008) and addressing the issue of finite mineral phosphorus resources (2010).

Of the four major nutrients needed for productive agriculture (N, P, K, S), potassium (K) and sulphur (S) are not in limited supply and do not require significant energy for processing and production.

Nitrogen

Nitrogen is effectively unlimited in the atmosphere, but requires considerable energy to fix via industrial processes. Nitrogen fertiliser manufacture is estimated at just over 1% of total world energy use. The process of producing ammonia industrially from natural gas (methane) is today optimised. Processes using other fossil fuels are considerably less efficient. The use of hydrogen from fuel cells, running on hydrocarbons or on nuclear or renewable electricity, is a possibility for the future.

A secure supply of methane is however, essential for world food security, and the authors suggest that natural gas reserves should be conserved for this purpose. They point out that the “flaring” of natural gas in the world’s oil fields involves quantities comparable to those required for nitrogen fertiliser production.

Phosphorus

In this (2011) paper, they also draw on the IFDC report on phosphorus resources (see *SCOPE Newsletter n°77*), which predicts a time frame for depletion of global phosphate rock at 300-400 years, significantly longer than other estimates of 100 years or less (Heffer et al. 2006, Smit et al. 2009, USGS 2010).

The authors point out that “*it is unclear ... how much reliance should be placed on the new projections*” and emphasise that even a horizon of 400 years is short in terms of human history and that such a **major threat to global food security, even at such a time horizon, cannot be ignored.**

Also, the highly localised known distribution of P-reserves (in a few countries) increases the risk of international tension and disputes, and **requires global cooperation to be established before serious P scarcity might start to occur:**

“national ownership of the reserves will have to be acknowledged and fairly recognised, access to their contents will have to be assured for all”.

Need for better P flow data

The authors indicate **the need for better, quantified, data concerning national and international flows of phosphorus,** in particular the estimation and separation of the losses of P-amended agricultural soil from losses of P in non-agricultural soil through erosion, in crops removed from fields and in manure discharges. This is essential to achieve evidence-based political and stakeholder agreement on policies and actions.

Earth-to-Earth Management

The global issues of nutrients (both P and N) and of food security can only be addressed by **managing nutrients in a closed cycle** (Earth to Earth), in particular developing recycling and reuse of nutrients from urban waste streams.

Food waste streams, for example from food processing, supermarkets, restaurants, need to be collected and the nutrients returned to farmland. For P, a significant proportion is found in bone ash.

Because of European regulations following the BSE (“mad cow” disease), much bone ash is still sent to landfill. The total P content in animal bones in the EU is estimated to correspond to 12% of total EU fertiliser and animal feed phosphorus imports.

Sewage P-recovery: need for new legislation

Today, only around 40% of P in sewage biosolids in the EU is returned to agriculture, and farm spreading faces obstacles of logistics (local nutrient excesses) and opposition from some stakeholders (contamination concerns).

As the human population becomes increasingly urban, the logistical difficulties of agricultural sewage biosolids spreading are accentuated, and **it will be necessary to develop systems which extract P from sewage in a form which can be stored and transported for use in industry or as a fertiliser.**

The annual permitted discharge of phosphorus to water (marine and inland waters) from UK sewage works (after treatment) is equivalent to approximately 0.36 kg

P/person/year, that is 40% higher than the recommended annual minimum dietary requirement.

The authors conclude that sustainable nutrient management will require systemic change, across all sectors, including coherent new legislation.

Producers and consumers both need to be involved, including optimised on-farm management, industrial-scale waste prevention and nutrient recovery and recycling, and changes in consumer habits, in particular the reduction of food wastes.

P resources and consumption

Phosphorus balance for Europe

Richards and Dawson (2008) provide an assessment of P-flows and sinks in Europe. The analysis covers the principal relevant tradable materials and hydrocarbon sources, fluxes to and from soil (agricultural soil P balance), fluxes to the sea (fish landings, discharge losses) and other minor flows. Tradable materials considered include: animals and animal products, crop products, human foods and animal feeds, ores and chemicals, consumables (plastics, leather), textiles, glass and metals.

In 2006 the EU imported (net of exports) some 1 415 000 t P (tonnes of phosphorus) in chemicals and ores, **mainly in phosphate rock** (1 073 000), **fertilisers** (507 000) and **phosphoric acid** (294 000). Outside this category, the largest net import of P was in human food and animal feeds, of which around ¾ of imported P was in soya bean oil cake for animal feed. Total net import of P in animal feedcakes was 162 000 t P, and total net import in all human food and animal feeds was 137 000 t P. Net import in crop products was a further 25 000 t P and in animals and animal products 6 000 t P. Textiles, glass, metals and consumables together only accounted for some 8 000 t P net imports.

Total net imports

Overall the total trade balance of P was estimated at 1 830 000 t P coming into Europe. To this must be added an estimated 134 000 t P in phosphate rock mined at Siilinjarvi, Finland, and 406 000 t P in other minerals and crude oil extracted in Europe.

Agricultural soil balance

Based on crop statistics, information on crop P content, data on garden wastes and forestry production, the authors estimated that some 2 190 000 t P was removed from land in Europe annually.

Based on data for fertiliser use, livestock numbers and livestock P excretion rates (assuming that all manure returns to land) and P in sewage biosolids and other wastes, the authors estimate that 1 315 000 t P were applied annually to land in fertiliser, 2 064 000 in manure and 115 000 in waste streams, that is a total of 3 494 000 t P.

Losses to the sea were estimated at 181 000 t P, based on EEA (European Environment Agency) data for river P discharges. It is noted that this figure is very estimative, and may be too low. 613 000 t P were estimated to be stored permanently in landfill, buildings (in minerals), etc. After taking into account other minor flows (fish landings, atmospheric precipitation, changes in human body P ...), **some 395 000 t P is calculated to be accumulating annually in European soils (8 kg P/hectare/year).**

The authors suggest that this is approximately the amount in the soil that might be expected to cease being readily crop-available through adsorption and reactions with calcium.

The authors conclude with the need to collate more accurate data, in particular for P in manures and P flows to and from agricultural soils.

Finite resource

Rethinking the options for phosphorus

Hilton, Johnston and Dawson (2010) present a detailed assessment of the P life cycle and options for conserving this finite resource. Data on phosphate rock resources and P-losses (at different points in production and use) are summarised.

The authors suggest that a sustainable equilibrium for P needs to be targeted through:

- Commercially viable, minimal-resource-depleting phosphate industry
- Socio-economic policy of minimal-depletion of P-resources

- Correct application of critical levels of P to crops to ensure food yield and quality in balance with human needs and the environment

Agricultural P conservation

The first major area for P management discussed is agriculture. P-uptake by plants can be affected by:

- Management of soil P concentrations
- Plant root system, related to soil structure
- Soil moisture levels
- Losses to weed growth

The authors discuss the behaviour of P in soils at the micro and the macro levels, the level of plant-available P necessary to achieve optimal yields, and how to add and maintain P to these levels.

P-recycling

The second major area for P-conservation is in recycling and reuse, including as possibilities agricultural use of phosphogypsum wastes, bone-ash, sewage biosolids, on-farm recycling of manure.

The authors suggest that phosphogypsum should no longer be considered a waste (economically, legally), but should be used for land reclamation, remediation of sodic/saline soils, or as an agricultural soil amendment (providing calcium, but also residual phosphorus). However, this may in some cases require pre-treatment of the phosphogypsum to remove residual acids, radionuclides or heavy metals, which may not be economic.

Sewage biosolids

Data from long-term agricultural experiments (1942 – 1960) are provided, showing that repeated application of manure or sewage biosolids to farmland increases both soil organic matter and plant-available phosphorus. **The authors note that P in sewage biosolids may be more or less plant available. In particular, where iron or aluminium salts are used in chemical P-removal, the iron or aluminium phosphates may “age” with time so that the P becomes less plant-available.**

The authors suggest that in developed countries, 25% of agricultural P requirements could be supplied by recycling from urban wastes and conclude that **now is the right time for significant changes in policies**

concerning P management, because of a context including rethinking of the post-2nd world war agricultural policy, upheavals in the phosphate industry (considerable new increased phosphoric acid production capacity in Morocco and Saudi Arabia), changes in general attitudes to recycling and legal frameworks for waste management, and sensibility to geopolitical risks related to raw materials resource scarcities.

“Fertiliser availability in a resource-limited world: Production and recycling of nitrogen and phosphorus”, Food Policy 36, S14–S22, 2011

<http://www.sciencedirect.com/science/journal/03069192>

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“Phosphorus imports, exports, fluxes and sinks in Europe”, IFS (International Fertiliser Society) Proceedings n° 638, 11th December 2008, ISBN 978-0-85310-275-5,

www.fertiliser-society.org

I. Richards, Ecopt, Ufford Road, Bredfield, Suffolk IP13 6AR, UK and C. Dawson, Westover, Ox Carr Lane, Strensall, York YO32 5TD, UK.

“The phosphate life-cycle: rethinking the options for a finite resource”, IFS (International Fertiliser Society) Proceedings n° 668, 15th April 2010, ISBN 978-0-85310-305-9,

www.fertiliser-society.org

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Switzerland

P-flows, recycling and social issues

Animal carcass wastes (MBM = meat and bone meal) contains a high level of phosphorus, and has for many decades been recycled as a valuable raw material in Switzerland, as elsewhere, in particular in animal feeds, fertiliser and in gelatin manufacture. However, BSE (“mad cow” disease) demonstrated health risks for certain uses, and led to the banning or consumer rejection of recycling. This paper presents a calculated phosphorus flow balance for Switzerland, showing the significance of animal wastes and identifying other key areas for P-recovery and recycling. The social trade-off between health risks and P-recycling, and between short-term and long-term issues, is discussed.

The authors' estimate phosphorus material mass balance for Switzerland includes 6 processes, 8 import and 4 export routes and 23 internal flows. Balances were calculated for 1989 (before BSE) and 2002 (after resulting changes).

Phosphorus flows

The largest flows (2002 figures) were between crop production and livestock (23 KtP/y plant materials used as animal feed) and animal excreta (21 KtP/y), giving a nearly closed cycle in agriculture. **Quantities of phosphorus imported (17 KtP/y) were 4-5x higher than that exported, including estimated runoff losses, showing a significant stocking of phosphorus in Swiss soils.** Nearly 3 KtP/yr is estimated to flow out of Switzerland annually in the Rhine river.

Significant quantities of phosphorus are found in different waste streams: 7 KtP/y in sewage (before treatment), 3.5 in solid wastes (including separately collected organic wastes) and 2.6 KtP/y in animal carcass wastes. About 30% of the phosphorus in sewage and wastes is returned to agriculture, most of the rest is lost to landfill. Animal carcass wastes are thus around 10% of total P in waste streams.

Between 1989 and 2002 Switzerland's phosphorus flows changed considerably. **Mineral fertiliser imports fell by 63%** from 17.4 to 6.4 KtP/y, with a consequent reduction in the annual accumulation of P in soils. This reduction is the result of changes in agricultural subsidies, for which ecological performance criteria (including balanced fertiliser use) were introduced.

Animal carcass phosphorus

In meat processing, only around 0.85 of the 4.5 KtP/y end up in meat, the rest goes to sewage, by-products and waste.

The P-flows of animal carcass waste P recycling in animal feeds and in fertiliser dropped from a total of 2.7 KtP/y in 1989 to nearly zero in 2002. Before the BSE crisis, 85 – 90% of waste animal bones in Switzerland were processed by Geistlich Agrasana, that is 50 – 60.000 tonnes of bones per year (containing some 1.5 KtP/y), **around 10 kg of bones per adult citizen per year.**

Following the first diagnosed case of BSE in Switzerland in 1990; the authorities progressively tightened regulations concerning the use of animal by-

products, finally banning all uses in animal feeds and fertilisers in 2001. At the same time, the gelatine market collapsed because of customer rejection. Instead of being recycled, bones were now incinerated in coal-burning power stations in Germany and animal meal incinerated in cement factories or waste incinerators in Switzerland, resulting in loss of the phosphorus to ashes and landfill.

Geistlich Agrasana stopped bone processing in 2006, after 155 years of activity. Certain Risk Category 3 bones (eg. pigs which do not carry BSE) are now exported to Europe for recycling.

Social trade-offs

The authors note that **animal bone phosphorus represents a significant potential for P-recovery and recycling (15% of phosphorus imports)**, and that this P-flow is readily recyclable because it is necessarily separately collected and contains a relatively high level of phosphorus. However, **reductions in agricultural P-losses and recovery of P from sewage and solid wastes** both offer potentially larger potentials.

The authors used **Structural Agent Analysis (SAA)**, based on interviews of actors such as waste management experts, authorities and scientists. Authorities acted on the "Precautionary Principle" to avoid risks of transfer of BSE pathogens (prions) in the food chain. The public, reacting to media coverage, reacted strongly, leading to withdrawal of animal waste recycled products by distributors. Decision makers also acted to try to reduce risks such as destruction of infected livestock, trade and reputation damage.

The cost of banning animal wastes in animal feeds and fertilisers was estimated at 27 million Euros/year, of which 75% was born by the taxpayer.

P-recovery from sewage

Similarly, and also for "Precautionary" reasons, **Switzerland progressively banned the agricultural use of sewage sludge** from 2003 to 2008, because of concerns about persistent contaminants. Sludge is now incinerated and the phosphorus thus transferred to ash from which it is at present not recycled, although processes exist to potentially do so.

In May 2007, the Canton of Zurich adopted a policy to recover and reuse phosphorus from sewage, although no timelines were fixed. Recently, a 2015

timeline for recycling via a dedicated incinerator for sewage biosolids has been set.

The authors conclude that **approaches to sustainable development cannot be limited to technical solutions**. Objective risk assessments are difficult, and are subject to many uncertainties. Intensive cooperation is therefore necessary between all concerned parties.

“The Trade-Off between Phosphorus Recycling and Health Protection during the BSE Crisis in Switzerland. A “Disposal Dilemma”, Gaia 20/2, 2011, pages 112–121
www.oekom.de/gaia

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P and people

Phosphorus and planetary boundary conditions

In two papers published together, the authors first present a simple model for assessing the planetary boundaries for phosphate supply in relation to human use with four scenarios for societal resource stewardship. The models are then used to look at how phosphate supply might fulfil or not human needs over coming centuries. It is concluded that both human population size management and effective nutrient recycling measures will be necessary to avoid world hunger and instability. Market mechanisms alone are considered inadequate to ensure that efficient use is developed before resources are largely consumed.

The scenarios considered are: end of pipe environmental problem management, clean production and pollution prevention, sustainable consumption and production, and fourthly sustainable population policy.

Current efficiency of phosphate use is only around 20% from mine to man, with around 36 kg/person/year of phosphate rock being mined, compared to physiological needs of only 7.3 kg/person.

Demand depends on world population

Phosphate demand depends principally on human population size, but with elasticity based on phosphate cost. This means that as high-grade, accessible resources are progressively consumed, then mining efficiency falls and phosphate prices increase, in turn leading to increased recycling.

In the very long term (around 1 000 years from now), when only low-grade phosphate rock resources remain, **this will push the human population down as soil phosphorus becomes depleted and crop productivity falls**.

The authors emphasise that the availability of nutrients to farmers is **strongly dependent on oil or energy**, for N fertiliser production and for transport and processing of phosphates.

The authors consider “peak phosphorus” production at different horizons, for peaks of high-grade, low-grade and very-low-grade rocks.

Market mechanisms inadequate

The models suggest that **price increases only occur after phosphate resources have become scarce, and so too late to avoid negative consequences**. This suggests that market mechanisms are inadequate to address phosphate resource stewardship, and that regulatory actions and public incentives to recycling are necessary.

The authors conclude that the only one of the four scenarios which leads to prosperity and stability, is the fourth one based on closed loop stewardship of nutrients and a sustainable international population policy.

“Challenging the planetary boundaries I: Basic principles of an integrated model for phosphorous supply dynamics and global population size”, and “II: Assessing the sustainable global population and phosphate supply, using a systems dynamics assessment model”, Applied Geochemistry 26 (2011) S303–S306 and S307–S310
www.elsevier.com/locate/apgeochem

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Water management

EU water policy

Sewage and water legislation review

A review of European water policy and legislation has been carried out for the EU Commission by Deloitte and IEEP (Institute for European Environment Policy). The report underlines that EU water legislation (in particular the Urban Waste Water Treatment Directive, Nitrates Directive, Floods Directive and Water Framework Directive) have improved water significantly across Europe, even if it is too early to assess the achievement of its core objectives by the Water Framework Directive. There are however questions concerning the rate of implementation.

The report concludes that there is no need for an overhaul of Europe's water legislation but emphasises that better integration of water objectives is necessary in EU policies and legislation on agriculture, buildings and urbanisation, and energy.

Sewage treatment

The 1991 EU Urban Waste Water Treatment Directive 91/271/EEC aims to reduce pollution of freshwater, estuaries and coastal waters by fixing standards and timetables for collection and treatment of domestic and industrial sewage and rainwater run-off.

In particular, **removal of phosphorus is obligatory (by 1998) in all sewage from towns or groups of villages of more than 10,000 person equivalent (usually around 6,000 population) wherever discharge is into waters potentially susceptible to eutrophication (that is, "Sensitive Areas").**

"Appropriate treatment" is also obligatory (by 2005) for all villages or groups of villages > 2,000 person equivalent, and this can be taken to mean nutrient removal in Sensitive Areas. Accession States have transitional deadlines extended by 10-15 years.

The report notes that **full implementation of the Urban Waste Water Treatment Directive is a "key condition"** for meeting the objectives of the 2000 Water Framework Directive. Progressive implementation of the Directive has considerably improved sewage treatment across Europe over the last 10-20 years, resulting in improvements in water quality, even if levels of connection remain lower in

Southern and Eastern Europe. Even in Western Europe, a number of agglomerations still lack full treatment.

According to the EU Commission's most recent data (2008), **93% of wastewater subject to obligations was collected, and 72% received tertiary treatment** (generally including phosphorus removal). For much of the sewage not receiving nutrient removal, this is because discharge is into waters not susceptible to eutrophication where this is not necessary or useful.

Implementation of this Directive is a major financial challenge, and the EU has made significant financial support to Member States.

Agriculture

The EU CAP (Common Agriculture Policy) is underlined to be the **"key driver of farming practices that in many cases have increased water pollution and scarcity"**, and the report indicates that this situation continues despite the reforms of the CAP in 2003 and 2008.

This is reflected in the difficulties of implementation of the 1991 Nitrates Directive 91/676/EEC. **Ten years after the adoption of the Nitrates Directive, many Member States had "scarcely begun to take it seriously"**. Implementation reports show that (by 2007), agricultural nitrogen emissions had decreased but still represented over 50% of total nitrogen discharges to surface waters. One third of European groundwater monitoring stations continued to show nitrate concentrations above 25 mg/l.

Water Framework Directive

The 2000 Water Framework Directive sets **the objective of achieving "good ecological and chemical status" for all European surface waters**, except under certain exceptions.

This may require **sewage treatment in smaller agglomerations, or to more demanding requirements**, than does the Urban Waste Water Treatment Directive, wherever this is necessary to achieve good quality in the receiving waters.

The Water Framework Directive, the report notes, is generally recognised as **"a good example of an integrated approach to environmental policy-making"** taking into account local river basin management.

Concerns have however been raised that its objectives are too ambitious and may prove very costly. Member States have requested derogations from either the “good quality” objectives or the standard implementation deadlines for nearly half of Europe’s water basins.

The **local flexibility** also raises questions about assessment and ensuring coherence of local interpretations of quality standards. Good information and data are important to ensure coherence and implementation, and remain a significant challenge.

Overall, it is considered too early to assess the objectives or implementation of this Directive.

Water availability, droughts and floods

The report considers that issues of water demand and availability, and of flood and drought management (including water efficiency requirements and cost-recovery) **need to be much better integrated into other legislation** such as agriculture, land use and buildings, and green energy policy (eg. hydroelectricity, energy crops).

Major legislation changes not needed

The report concludes that **major changes of EU water legislation are not necessary**, and this is confirmed by the response of EU Environment Commissioner Janez Potoc’Nik. Mr Potoc’Nik also indicated that the Commission is now considering mandatory water efficiency standards for buildings, and better integration of water into agricultural policies.

“European Commission – General Directorate Environment, Support to Fitness Check Water Policy”, 14th June 2011, 223 pages

Deloitte Consulting and IEEP (Institute for European Environment Policy)

Available at:

www.ieep.eu/assets/826/Water_Policy_Fitness_Check.pdf

Wastewater reuse

Fertilising eggplant and tomato crops

Much of Burkina Faso’s sewage, as well as industrial wastewaters (breweries, abattoirs ...) is discharged untreated into rivers and canals, from where it is pumped and used by market gardeners producing food crops. 48 such sites with some 175 ha of production were identified in Ouagadougou

alone in the 1990’s. This has led to concerns about human health risks, and quality of vegetables and soils. However, the reuse of wastewater is also essential to alleviate water shortages and enable irrigated agricultural food production.

This paper presents **experimental irrigation of tomato and egg plant crops** in 6 - 9 m² field plots, at the Institut International d’Ingénierie de l’Eau et de l’Environnement (2iE), Ouagadougou, in 2001, 2002 and 2003, **comparing macrophyte-pond treated wastewater to relatively clean freshwater** (Loumbila dam), in both cases with and without mineral fertiliser addition. Each treatment had three replicates.

Macrophyte treated sewage

The treated wastewater was collected from the ponds of the Institute’s *Pistia stratiotes* ponds (treatment capacity 6 m³/day), which is fed with wastewater from the Institute’s student residential buildings after primary treatment

Irrigation and nutrients

All plots were irrigated at 6 mm/day (first month after transplanting seedlings) then 9 mm/day, calculated to correspond to dry season evapotranspiration rates. **Two different irrigation techniques (from the side, and from-above on the foliage) were used**, to enable comparison of resulting pathogen contamination levels. For the treatments with added mineral fertiliser, the fertiliser was added according to recommended agronomic nutrient dosages for Burkina Faso, in 2 – 3 applications (15, 30, 50 days after transplanting for tomato), without deducting nutrients also present in the dam or wastewater.

Nutrients concentrations present in the treated wastewater were very variable, covering much of and in some cases all of crop nitrogen needs, but only 3 – 60% of crop phosphorus needs. The dam water did not contain significant N or P. Crop potassium needs were largely covered both by the wastewater and the dam water.

Irrigation with treated wastewater only (without added mineral fertiliser) significantly increased average egg plant crop yield, but not tomato crop yield..

Health risks

Faecal coliforms in both the treated wastewater and the dam water were low enough to be conform, on average, to WHO recommendations for irrigation

water to be used on uncooked fruit and vegetable crops. However, **soils irrigated with both waters showed contamination** with both faecal coliforms and helminth eggs. Contamination was found in fruit only for tomatoes irrigated directly on foliage using treated wastewater in one year.

The authors conclude that macrophyte pond treated sewage can be used to irrigate market garden crops, with limited risk of microorganism contamination or health risk. However, addition of some mineral fertiliser may also be necessary because the wastewater does not fully provide crop needs, if applied as necessary for plant uptake, in particular for phosphorus.

They also recommend that market gardeners develop the use of side-on irrigation techniques, delivering water below the level of foliage and fruit, in order to reduce the risk of microorganism traces on fruit.

Agricultural Water Management, n° 98, pages 834-840, 2011 www.elsevier.com/locate/agwat

“Reuse of domestic wastewater treated in macrophyte ponds to irrigate tomato and eggplant in semi-arid West-Africa: Benefits and risks”, P. Akponikpe (1,2), K. Wima (2), H. Yacouba (2), A. Mermoud (3). akponikpe@yahoo.com

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Recycling sewage nutrients

Apartment-scale wastewater crop fertilisation

In Mexico City, ozone treated domestic wastewater was tested as a source of nutrients for the production of vegetable crops in simple apartment-scale units made from recycled materials. The ozone treated wastewater was compared to tap water and to untreated wastewater, for crop fertilisation, presence of micro-organisms (possible health risk), toxicity to seeds and soil quality.

Simple containers were made out of old tyres and plastic packaging materials, then filled with garden

waste (dead leaves) and chopped fruit and vegetable wastes, covered with a thin layer of soil. Germinated seedlings of different crop plants (radish, tomato, spearmint, camomile, Romaine lettuce, Chinese cabbage) were grown in combinations intended to discourage pests.

Domestic wastewater, after primary treatment to remove floating and suspended solids, was used to fertilise the plants and provide nutrients, with three treatments: tap water, wastewater, ozonated wastewater (O₃). The wastewater contained 530 – 575 mg/l total nitrogen N, and 5 – 6.4 mg/l total phosphorus P.

Ozonation

Ozonation was carried out for one hour in a 5 litre reactor (1 litre/minute ozone flow from a Laboratory Ozoniser (Emery-Trailigaz Labo 76), resulting in an average ozone concentration in the treated wastewater of 7.36 mg/l at pH7, 23°C.

Plant fertilisation experiments were made in quintuplicate (total 45 containers) and ran for 6 month periods, with a spread of growth and harvesting of the different plants as appropriate (radish at 30 days, Chinese cabbage 4 months). In all cases, 5 litres/week of (waste)water was applied.

Toxicity to seeds was tested in petri dish incubation experiments, using different concentrations of ozonated and not ozonated wastewaters, testing germination after 5 days.

Analysis showed that ozonation removed BOD, COD, coliforms and helminth eggs from the wastewater, but did not affect nutrient levels (N, P).

Low seed toxicity, high crop growth

Seed germination and initial growth (5 days) were statistically **significantly better in the ozonated wastewater** than with the not ozonated. The authors suggest that this may be because of toxic substances in the wastewater which are destroyed by the ozonation.

Ozonated wastewater also showed the optimum results for crop growth (eg. average length 6.02), better than non ozonated wastewater (5.47), which in turn was better than tap water (5.39). No plants died under any of the treatments.

Soil nutrients were depleted after the 6 month experiment in the tap water containers, whereas **in the**

wastewater containers both N (nitrogen) and P (phosphorus) were still present at levels appropriate to support further cropping, but also micronutrients / contaminants had also increased (Ca, Mg, Na, Fe, Mn, Zn, Cu, Pb, Ni, Cd).

The authors suggest that the ozonation may not only ensure sanitisation of the wastewater, but also **contribute to oxygenation of soil**, thus avoiding plant growth inhibition effects of excessive nutrient dosage and improving plant nutrient uptake. This could explain the better crop production in the containers fertilised with ozonated compared to non ozonated wastewater.

*“Urban agriculture, using sustainable practices that involve the reuse of wastewater and solid waste”,
Agricultural Water Management in press 2011*

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Conferences and publications

Phosphates 2012

Phosphate industry conference

The 2-yearly conference for the worldwide phosphate industry (rock production, fertiliser, animal feeds, food, detergents, other industrial uses) will take place in El-Jadida, Morocco, 19th - 21st March 2012:

- Phosphate rock production and project developments
- Global fertilizer outlook with a focus on key country demand projections and requirements
- Developments in optimizing / streamlining and maximizing the phosphate resource
- Survey of changing industrial phosphate demand, update of regulations and substitutes
- Outlook of future feed phosphate demand and focus on regional growth

The event also offers site visits to the Jorf Lasfar Chemical Facility and to the Khourlbga Mine Facility.

<http://www.crugroup.com/events/phosphates/>

Toulouse, France, 23rd November 2011

Recycling and reuse of phosphates from effluents

This seminar will look at the issues surrounding phosphate recycling, P-recovery processes, phosphate precipitation, uses of recovered phosphate products.

The seminar will include a presentation of the Phosph'OR continuous process for precipitating and recovering struvite from treated pig manure (Cemagref), the LISBP process for recovery of phosphate by biological granulation, processes for recovery of phosphate from domestic sewage, methods and models for struvite precipitation, regulatory issues and plant availability of recovered phosphates.

Organised by INSA Toulouse, Cemagref, LISBP and Midi-Pyrénées Innovation.

8h30 – 17h00 Wednesday 23rd November 2011
INSA Toulouse, France
In French

<https://phosphor.cemagref.fr/events/FlyerP.pdf>

Phosphorus cycle

Chemosphere special issue

Chemosphere journal (Elsevier publishers) has published a special issue on “The Phosphorus Cycle”: Chemosphere, Volume 84, Issue 6, Pages 735-854 (August 2011).

Articles cover the history of phosphorus ; nutrient recovery and reuse ; phosphorus resources, cycles and flows ; global phosphorus security and phosphorus in food production.

Individual articles can be purchased on the Elsevier ScienceDirect website:

<http://www.sciencedirect.com/science/journal/00456535/84/6>

or paper copies of the full special issue can be purchased for €160,50 (ex VAT, inc. price for postage to Europe) from

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