Recovered products that can be used directly as fertilizers: organic fertilizers

Closing the nutrients cycle

Unsustainable agricultural and wastewater disposal practices pose an irreversible threat to global and water resources. Researchers at the Fraunhofer-Institut in Germany, **Jennifer Bilbao**, **Maria Soledad Stoll** and **Siegfried Egner**, are investigating strategies for reusing the nutrients

Production of enough food, access to clean water and adequate management of solid and liquid wastes will be an immense challenge for humanity, taking into account that 9B people will inhabit the Earth by 2050. Current global practices in agriculture and waste disposal systems are threatening the future global food security. There is an urgent need to develop new approaches to manage vital resources within the global food production and waste treatment to achieve sustainability.

Nutrients such as nitrogen, phosphorus, or potassium are not only essential to agriculture, but also to all living organisms. These nutrients are not yet sufficiently integrated in a closed material flow (Figure 1). Rather, the material flow begins by adding nutrients as fertilizer to the crops; the plants take up the nutrients, which are withdrawn from the plant-soil ecosystem by harvesting. These plants are used for the production of food, bio-energy and bio-materials. Once these products are consumed, a large part of these nutrients are lost in the established waste disposal systems, as these materials are usually not taken back into the soils. In order to compensate this lack of nutrients additional industrially manufactured mineral fertilizers or organic fertilizers must be added to the soil.

The industrial production of these mineral fertilizers is based on non-renewable products. In the case of phosphorus, the main source for fertilizer production is phosphate rock. Many studies indicate that the phosphate reserves will be depleted within 50-100 years and that demand will exceed supply by 2030 (see page 34).

Phosphorus is an element indispensable for life, which cannot be manufactured, synthesized, or replaced by any other element. In contrast, nitrogen is available from the atmosphere. Nitrogen fertilizers are synthesized using the Haber-Bosch process, which transforms gaseous nitrogen from the air to ammonia (NH_3). This production of synthetic NH_3 is energy-consuming and based on non-renewable natural gas using about 5% of its global consumption.

With the growing world population, the demand for food, bio-energy and bio-materials will continue to increase, which in turn will lead to a higher demand for fertilizers. As a consequence, the prices for fertilizers will rise, which will cause a decrease in farm production, higher food prices, growing food insecurity and rising social and economic challenges that the next generations will have to face.

Paradoxically, as we run out of raw material for producing fertilizers, large quantities of nutrients are lost in the sewage system. The state of the art in most municipal wastewater treatment plants is to remove nitrogen-compounds like ammonium and nitrate from wastewater by nitrification/denitrification processes is increasing.

In this process, these compounds are converted to gaseous nitrogen that just escapes to the air. Phosphate is removed by a chemical precipitation with aluminium or iron salts. Aluminium and iron phosphate cannot be used as fertilizers. These phosphates are either not plant-available or could release iron and aluminium in toxic concentrations for the plant. Approximately 4.3m tonnes of phosphorus are lost in this way per year worldwide.

Mineral fertilizers are often over-fertilized in agriculture, and thus leading to a further drain of nutrients into surface water, causing water pollution like eutrophication. Organic fertilizer such as manure or digestates from biogas production could also be applied to the soil. However, these organic fertilizers do not contain the right proportion of nutrients that the plant in question requires. The use of uncontrolled quantities of nutrients in organic fertilizers can also result in over-fertilization and thus be harmful for the environment. Only in Germany, over 70% of the nitrogen and 50% of the phosphorus input into surface waters originated from agriculture sources during 2003 to 2005.

The Fraunhofer Institute for Interfacial Engineering & Biotechnology (IGB) has recognized that the key response to this lack of sustainability within agriculture and waste management is to re-create a cycle of nutrients (Fig1). Fraunhofer IGB has begun to develop cost-efficient strategies and technologies for the recovery of nutrients from wastewater and organic residues. Solid and liquid wastes are being evaluated in terms of nutrient content and nutrient recovery potential.

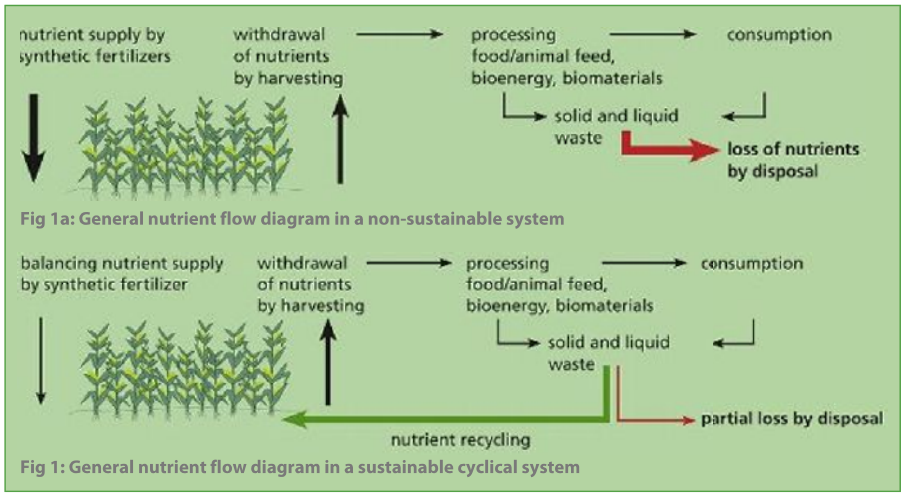

Fig 1a: General nutrient flow diagram in a non-sustainable system

Fig 1: General nutrient flow diagram in a sustainable cyclical system

A novel process is being developed to recover magnesium-ammonium-phosphate, potassium-magnesium-phosphate and calcium phosphate. In a project funded by the EU, research is being undertaken into the recovery of nutrients from olive oil wastes.

The recovery of nutrients from animal manure and their recycling as a fertilizer for the cultivation of cabbage is being investigated in a further EU-funded project.