

TRAINING MATERIAL

Title:

The use of **mineral concentrate** as fertilizer

Training:

Main features of the subcategory

Mineral concentrate is the concentrated mineral nutrients solution obtained from separation process (e.g. membrane filtration or evaporation) of waste streams that concentrates the mineral nutrients in the end-product compared to the input.

Mineral concentrates predominantly consist of ammonium-nitrogen and soluble potassium. The main driver for the production of mineral concentrates is to prevent transport of liquid streams with low nutrient contents or to tailor the ratios of nutrients (nitrogen, potassium and sulphur) in the fertilisers to meet the requirements of crops. Analysis across ten pilot plants in the Netherlands showed that the mineral concentrates produced from reverse osmosis (RO) concentration process contains on average 90% of the total nitrogen in the form of $\text{NH}_4\text{-N}$. The ingoing liquid fraction contains some organic matter which is present in mineral concentrates (1.3% organic matter or 0.6% organic carbon). Compared to pig slurry the ratio between $\text{NH}_4\text{-N}$ to Total N increased from 66% to 90%.

Input material

Liquid fraction of waste streams rich in mineral nitrogen and phosphorus, including urine or slurry from animal husbandry, effluent of anaerobic digestion, dehydrated effluent from wastewater treatment plant.

How to produce?

The first step of the process is a solid-liquid separation by means of a decanter centrifuge, auger press or belt press. This leads to a solid fraction and a liquid fraction. In the process integrated with membrane technologies, the liquid fraction is processed further to remove particles by DAF (dissolved air flotation units), ultrafiltration, nano-filtrations and paper filters. Coagulation and flocculation processes can be stimulated by use of flocculants. The cleaned effluent enters a single or multiple concentration steps using reverse osmosis (RO) unit. Water is pushed under pressure through semipermeable membranes leading to a concentrate of minerals and a permeate (cleaned water). Fouling of the membranes by salts and microorganisms requires regular cleaning and maintenance. The permeate can require an additional treatment by means of an ion exchange resin before discharging to surface water or the soil becomes possible. In other processes, the liquid fraction after separation can also be directly concentrated by an evaporator operated under vacuum or heated conditions.

Typical nutrient content and availability for plants

The mineral concentrate from RO process usually contains N 5-9.5, P₂O₅ 0-0.1 and K₂O 6-11 kg/ton (ID:520-593-1504) and even 65 kg/ton K₂O after further evaporation (ID:1528).

Examples for mineral concentrate products available on the NUTRIMAN Farmer Platform

- https://nutriman.net/farmer-platform/product/id_520 (Netherlands)
- https://nutriman.net/farmer-platform/product/id_593 (Netherlands)
- https://nutriman.net/farmer-platform/product/id_1504 (Netherlands)
- https://nutriman.net/farmer-platform/product/id_1528 (Netherlands)



Figure 1 Vlako mineral concentrate (ID:520)



Figure 2 Maatschap Verhees' mineral concentrate application (ID:593)



Figure 3 VP-Hobe system for mineral concentrate production (ID:1504)



Figure 4 VP-Hobe system for NK concentrate production (ID:1528)

The mineral concentrate from pig/cattle slurry using belt press sieve and reverse osmosis processing (ID:520) is provided by Vlako. The mixed slurry from 95% pigs and 5% cattle or mink is separated in a solid and liquid fraction using a belt press sieve. The solid fraction is pasteurized and exported. By processing the liquid fraction with reversed osmosis, the mineral concentrate is separated from clean water. The clean water is used for sub-surface drainage irrigation. The mineral concentrate from Vlako is liquid and contains on average N 5-9.5, P₂O₅ 0.1 and K₂O 6-11 kg/ton.

Mineral concentrate from pig slurry using belt press sieve and reverse osmosis processing (ID:593) is produced by Maatschap Verhees in the Netherlands. The product contains urea and ammonium nitrogen. Average content varies due to the natural origin of the product: N 5.0-6.5; P₂O₅ 0.0-0.1; K₂O 6.0-9.0 kg/ton.

Mineral concentrate from pig manure or digestate with VP-Hobe Manure Valorisation system (ID:1504) is also produced in the Netherlands. The produced Mineral Concentrate is a liquid fertilizer with 0.8% N and 0.9% K₂O in 3.4% DM. They also produce another concentrated N/K₂O product by further de-watering in an evaporator (ID: 1528) The liquid passes through a falling film evaporator with mechanical vapour recompression. Heating the liquid in the evaporator causes water to evaporate. A vacuum lowers the boiling point, less energy is needed than when evaporating at normal atmospheric pressure. The ammonia in the incoming liquid is removed from the product flow by stripping and scrubbing the vapour coming out of the evaporator with sulphuric acid into ammonium sulphate. The evaporator reduces the nitrogen and potassium concentrate to 25% DM and 6.5% K₂O.

Fields of application in agriculture: crop, dosages, application method and practical recommendations.

The mineral concentrate can be used in conventional farming, covering fresh vegetables, root crops and plants, grain maize and corn-cob, permanent grassland and dry pulses and protein crops. The recommended application dose depends on the crop needs and soil analyses. Currently the max is 170 kg N/ha as livestock manure (230-250 kg N/ha for derogation dairy farms). In The Netherlands it is accepted as pilot RENURE fertilizer defined as the processed manure fractions that can replace chemical fertilizers. Application can be done using regular liquid manure injection systems. Low emission application techniques are compulsory to prevent ammonia volatilization. The mineral concentrate can be mixed with manure/slurry and/or diluted with water prior to application on grassland.

Benefits for farmers

The N and K in mineral concentrate from RO process (ID:520-593-1504-1528) are mostly plant available, which shows higher nutrient value compared to unprocessed manure. The N and K recovery from manure contributes to closing agricultural nutrient cycles. The product is locally produced for local farmers. Agronomic effectivity of mineral concentrates has been tested under controlled conditions in pot experiments and in field experiments on arable land and grassland. Potassium is equally effective as mineral potassium fertilisers. The fertiliser value of the reference chemical fertiliser is set at 100% although this does not mean that chemical fertilisers are for 100% effective. To prevent ammonia volatilisation, mineral concentrates require shallow placement or need to be injected into the soil. The nitrogen fertilizer replacement value (NRFV) is determined by comparing with chemical fertiliser as reference. Under controlled conditions (pot experiments) mineral concentrates are almost comparable with calcium ammonium nitrate (NFRV is approaching a full replacement value of 100%). In the field situation attention still has to be given to the application technique (surface broadcast or injection). The environmental performance of mineral concentrates was tested by looking at their effect on nitrate accumulation in soil, nitrate accumulation in groundwater, ammonia volatilisation and emission of greenhouse gasses. There is no evidence that mineral concentrates increase nitrate concentration in groundwater. In fact relatively low values are measured compared to the application of calcium ammonium nitrate (CAN) and pig and cattle slurry. This is also the case for nitrate accumulation in the soil where mineral concentrates show the lowest levels of concentration. To prevent ammonia volatilisation, mineral concentrates need to be incorporated into the soil. N₂O emission caused by mineral concentrates is higher compared to CAN but lower when compared with the chemical fertiliser urea. Overall agronomic and environmental performances of mineral concentrates is in line with chemical nitrogen fertilisers.

Bottlenecks of application. Potential risk or limitation.

As a product recovered from manure, these mineral concentrates (ID:520-593-1504-1528) is legally treated as manure and therefore they cannot be used as chemical fertilisers in terms of the Nitrates Directive. Currently this product has to compete with animal manure and has therefore no financial value yet. An effort is needed in a further concentration step to meet proposed criterions of liquid fertilising products of the new facultative European regulation of fertilising products if free trade within the EU is an objective. Finally, mineral concentrates are products of manure and thus have to meet requirements of the regulations on animal byproducts.

Legal framework for usingSpecific national legal conditions

These four mineral concentrate products (ID:520-593-1504-1528) are all from the Netherlands and follow the Dutch fertilizer act (Meststoffenwet). It is allowed as pilot

RENURE fertilizer in NL which means that application is no longer defined as livestock manure in the Nitrates Directive. The product has a pilot approval pending the official acknowledgement by the EC. Therefore application is not limited to max 170 kg N/ha.

EU Fertilising Products Regulation

ID:520 fits in the EU Fertilising products regulation 2019/1009 PFC 1 C (I)(b) as a liquid inorganic macronutrient fertiliser.

ID:593 fits in the EU Fertilising products regulation 2019/1009 PFC 1 B (II) as a liquid organo-mineral fertiliser.

ID:1504 fits in the EU Fertilising products regulation 2019/1009 PFC 1 C (I)(b) as a liquid inorganic macronutrient fertiliser.

ID:1528 fits in the EU Fertilising products regulation 2019/1009 PFC 1 C (I)(b) as a liquid inorganic macronutrient fertiliser.

Economic evaluation of the application of the products

The cost for farmers to use product ID:593-1504 will be approximately €0 per ton delivered to the field (excluding application costs) and €0-5 for ID:520 while for ID: 1528 approximately €5-10 per ton ex works.

Best management practice guideline, taking into account of specific conditions of the given territory, for the use of the product to the specific applications (soil improvers, growing media, organic fertilisers etc.).Application doses

- Mineral fertilizers:
 - ID:520-593-1504 → depend on crop needs and soil analyses, currently max 170 kg N/ha as livestock manure in terms of the Nitrates Directive.
 - ID:1528 → 6-10 t/ha according to the application of K₂O at 200-300 kg /ha; application rates depend on crop needs and soil analyses

How to store, apply to land, machinery needs.

The mineral concentrate should be stored in closed containers and placed in dry place without directly expose to the sunlight. This will prevent volatilization of ammonia which reduce the N fertilizer value. As the high concentration of ammonium it is necessary to be very careful when transporting and applying on field.

For more information:

- https://nutriman.net/farmer-platform/product/id_520 (Netherlands)
- https://nutriman.net/farmer-platform/product/id_593 (Netherlands)
- https://nutriman.net/farmer-platform/product/id_1504 (Netherlands)
- https://nutriman.net/farmer-platform/product/id_1528 (Netherlands)