analisi r&s tecnologie ambientali
SERECO BIOTEST

SISTEMA QUALITA' ISO 9001 REG. N. 3957

STRUTTURA CONVENZIONATA CON L'UNIVERSITA' DEGLI STUDI DI PERUGIA

an environmental high tech shuttle structure

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SERMAP®. a novel system for the removal of nitrogen high loads in manure and zootechnical wastewaters

In the years 2004-2005 Sereco Biotest carried out a research supported by the Italian Ministry for Economic Development aimed at adjusting, at a real plant scale, a system for the removal of ammonia with the recovery of organomineral fertilizer. This process has been named SERMAP®.

The study has been carried out, in collaboration with the Department of Chemistry of the University of Perugia, at a big anaerobic digestion facility for swine wastewater, CODEP located in Bettona (Perugia, Center Italy). This plant treats about 1000-1200 mc/day of zootechnical wastewaters from about 80000 pig heads.

The interest towards this process stems from the fact that many regional authorities have denied the authorization to many biogasification projects, due to the lack of sound methods for nitrogen removal that could assure the compliance with the EC “Nitrate” Directive.

The SERMAP® process makes it possible to remove ammonia both from raw zootechnical wastewaters and anaerobic wastewaters, by transforming it into a precious and slow-release valuable ternary fertilizer made up of struvite (Esahydrate Magnesium Ammonium

Phosphate), thus reducing the ammonium concentration in wastewater down to values compatible to nitro-denitro biological processes. It is noteworthy that the nitrifying flora is inhibited when the concentration of ammonia is higher than 400-500 mg/l.

In particular, the SERMAP® process has been set-up and tested on 24 m^3 batch volumes of anaerobic wastewaters (fig 1) in the CODEP anaerobic treatment plant.

Fig. 1 – Overview of the experimental plant

The plant has been fully automated through a system comprising novel electrochemical sensors and an in-housed process control software coupled to a PLC (Fig.2).

Fig.2 Automated control position of the SERMAP® plant with the in-house software

The results obtained have proved to be extremely satisfactorily, reaching an ammonium abatement, in the liquid phase, being over 70% (with peaks of 90%). In economically optimised experimental runs, a mean ammonium abatement has been reached so that the ammonium mean concentration in the SERMAP® outflow was around 250-350 mg/l. These values are compatible with the well-known nitro-denitro biological treatment. The treatment cost[1] in these case, oscillate between 0,8 and 2.1€/m^3 (Tab.2 e Tab.3), in relation to the desired nitrogen removal rate The cost of the treatment is widely traded-off by the SERMAP® fertilizer value, which represents a highly precious, slow-release fertilizer with a high sustainability from an environmental point of view.

TABLE 1 – In-flow and out-flow ammonium concentration for the SERMAP® plant

(Tests carried out on the out-going anaerobic wastewater without centrifugation)

Run	RM	NH_4 in	NH4 out	Abatement Efficiency%
	NH_4:Mg:PO_4	mg/l	mg/l	%
1	1:0.6:0.6	930	450	**51,6**
2	1:0.8:0.8	1503*	432	**71,3**
3	1:0.9:0.9	860	420	**51,2**
4	1:0.8:0.8	917	200	**78,2**
5	1:0.7:0.7	990	220	**77,8**
6	1:0.6:0.6	765	460	**39,9**
7	1:0.8:0.7	900	270	**70,0**
8	1:0.7:1	1560*	325	**79,2**
9	1:0.7:1	1030	340	**67,0**
10	1:0.7:1	1288	350	**72,8**

[1] 2005 values. For an updated evaluation please contact Dott. Luca Poletti sereco@serecobiotest.it

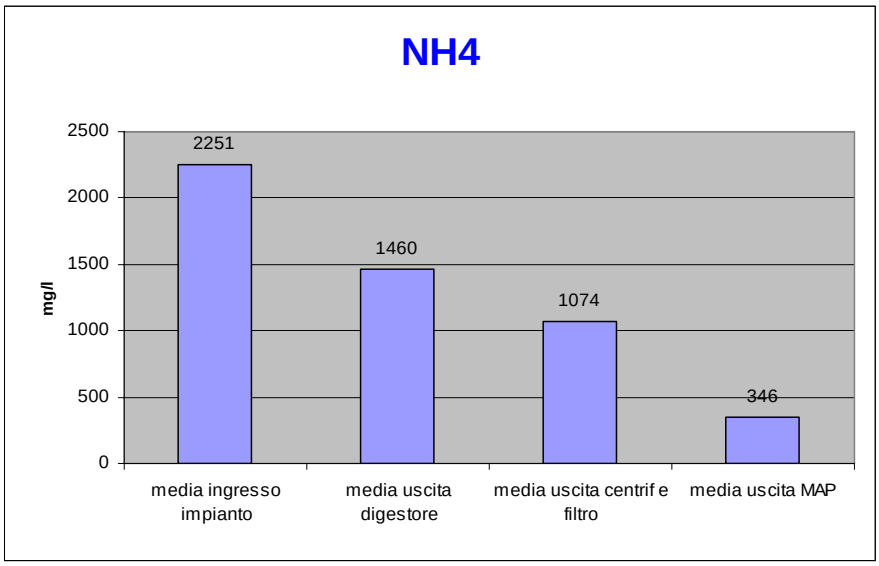

Fig.3 – Mean concentration of NH_4^+ at different phases of the SERMAP® process

TABLE 2

COSTS AND REVENUES OF SERMAP® PROCESS INCLUDING STRUVITE SALE (ABATEMENT < 70%)

CASO A: % ABATEMENT < 70%	AVERAGE	AVERAGE discounted prices*	MIN	MAX	MIN discounted prices *	MAX discounted prices *
COST €/m^3	1,54	1,10	1,12	2,12	0,80	1,51
Kg / m^3 produced STRUVITE	9	9	9	9	9	9
Revenue €/ m^3 (@0.20€/Kg)**	1,80	1,80	1,80	1,80	1,80	1,80
Net revenue €/ m^3	0,26	0,70	0,68	-0,32	1,00	0,29
Revenue €/ m^3 (@0.25 €/Kg)**	2,25	2,25	2,25	2,25	2,25	2,25
Net revenue €/ m^3	0,71	1,15	1,13	0,13	1,45	0,74
Revenue €/ m^3 (@0.30€/Kg)**	2,70	2,70	2,70	2,70	2,70	2,70
Net revenue €/ m^3	1,16	1,60	1,58	0,58	1,90	1,19

* 30% discount on reagents by operating the purchase of bigger volumes upon supplier negotiations

** average price on the european market 200-250 €/t. In other countries (USA) the market price of the so called "boutique" fertilizers, like struvite, is 283 $ /t (about 218 €/t).

TABELLA 3

COSTI E RICAVI DERIVANTI DAL PROCESSO SERMAP® E DALLA VENDITA DELLA STRUVITE

(ABBATTIMENTO > 70%)

CASO B: % ABATEMENT > 70%	AVERAGE	AVERAGE discounted prices*	MIN	MAX	MIN discounted prices *	MAX discounted prices *
COST €/m^3	1,96	1,40	1,19	2,95	0,85	2,10
Kg / m^3 produced STRUVITE	13	13	13	13	13	13
Revenue €/ m^3 (@0.20€/Kg)**	2,60	2,60	2,60	2,60	2,60	2,60
Net revenue €/ m^3	0,64	1,20	1,41	-0,35	1,75	0,50
Revenue €/ m^3 (@0.25 €/Kg)**	3,25	3,25	3,25	3,25	3,25	3,25
Net revenue €/ m^3	1,29	1,85	2,06	0,30	2,40	1,15
Revenue €/ m^3 (@0.30€/Kg)**	3,90	3,90	3,90	3,90	3,90	3,90
Net revenue €/ m^3	1,94	2,50	2,71	0,95	3,05	1,80

* 30% discount on reagents by operating the purchase of bigger volumes upon supplier negotiations
** average price on the european market 200-250 €/t. In other countries (USA) the market price of the so called "boutique" fertilizers, like struvite, is 283 $ /t (about 218 €/t).

An accurate techno-economical and ecological analysis, based on LCA (Life Cycle Analysis), has demonstrated that SERMAP®, coupled to a subsequent nitro-denitro SBR (Sequencial Batch Reactor) (Fig.4), is effective in achieving the direct discharge of the effluent into superficial water bodies or soils in compliance with domestic and european regulations. Also the recover of water for irrigation purposes is possible following the application of the SERMAP® processing.

The process can be modulated in relation to the desired nutrient removal rate, that can be fixed according to different factors such as: initial nitrogen concentration, daily volume of wastewater, quantity of fertilizer wanted, soil availability for sparging, availability and costs of reagents.

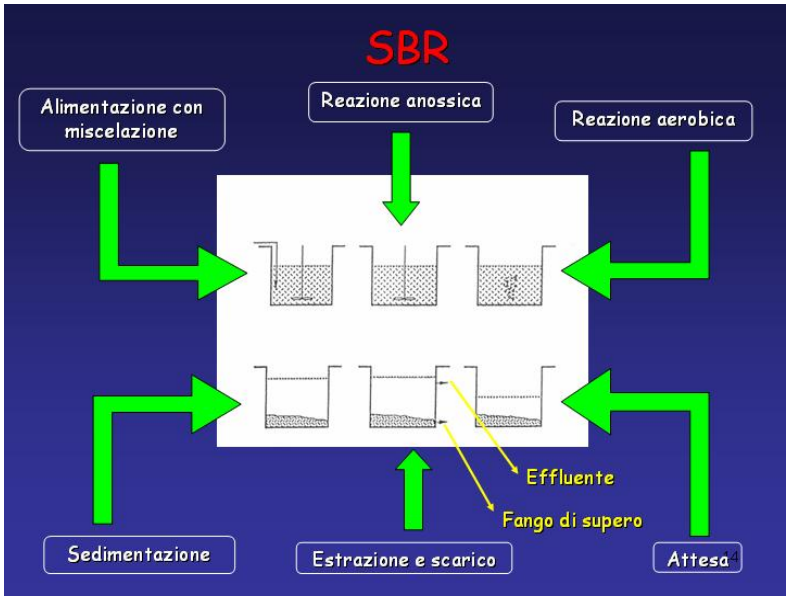

Fig. 4 Process scheme of nitro-denitro SBR

SERMAP® (Fig. 5 and Fig.6) is a valuable product as it was demonstrated by carrying out thermogravimetric measurements, because the ammonium ion only gradually releases from the crystals at ambient temperature, independently from the temperature, up to 60-70°C.

Fig. 5 MAP slurry (mixed liquor)

Fig. 6 MAP ENT (Essiccato Naturale Tecnico, Technical Natural Dried)

Beyond this temperature range the decomposition becomes faster. Moreover, the SERMAP solubility on neutral water is very low and gradually increase with decreasing pH values.

From all that, it derives that the SERMAP® process is characterized by an extremely low nitrogen volatilisation and a low solubilization of the anionic and cationic components, especially in acidic soils and can be categorized as a slow-release fertilizer. Moreover, the presence of six crystallization water molecules contributes to the nutrient microsolubilization induced by the enzymes of the radical apparatus. For all this, the SERMAP® fertilizer can be used according to vegetable bio-request. In this way, the risk of nitrate leaching affecting waterground resources can be eliminated once the free ammonia has been biologically nitrified.

The encouraging results obtained in this first experimentation have supported the belief that the SERMAP® process can be effectively implemented in all the situations in which the removal of high nitrogen loads is seeked.

The process encompasses not only a valid technical solution but also a new philosophy: the recovery of material and energy from high-entropy materials with the aim of achieving, with the highest yield, an optimized full closing of the thermodynamical cycle “sun-soil-vegetables-meat-soil”, characterized by the upgrading thinking: “**from disposal to recovery**”.

To sum up, the interesting elements in SERMAP® process are many, including:

1. avoid the loss of nitrogen and other elements like phosphorous, magnesium, calcium, potassium and other mineral oligoelements, all of them being extremely precious from an agronomical point of view;
2. comply to the EC directive dealing with the elimination and containment of nitrogen emissions into the atmosphere (particularly ammonia and nitrogen oxides) as primary cause of acid rains;
3. appreciably contribute to the containment of bad odours by reducing the diffusion of ammonia, hydrogen sulphide and volatile acids as the process determines their salification and therefore loss of volatility;
4. overcome the constraint of soil availability, that regulates the sparging of digested water according to the “Nitrate” directive;
5. save high amounts of energy necessary to reduce the anaerobic nitrogen load when biological nitrification has to be performed
6. save money on the structural adjusting of the plant. In the case of the CODEP plant, the SERMAP® plant has been set up by only reutilizing decommissioned facilities (basins, tanks, pumps, etc…) already being present in the plant area, without an euro being spent towards the erection of new structures, nowadays much more expensive than it was a few years ago, due to the raising of the costs of building materials (iron, cement, etc…);
7. carry out the denitrification process without the supplementation of methanol or other forms of organic carbons, as the SERMAP® process selective eliminates nitrogen without affecting the carbon load;
8. introduce on the market a slow-release fertilizer that can contribute to the elimination of groundwater pollution and saving, in loco and over time, nutrients (N and P) according to the biorequest of the plant radical apparaturs

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