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Challenging Status Quo… but what about residuals?

Aquaculture Innovation Workshop, Vancouver 2017

By Lars Rohold, Scanship AS

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Scanship ongoing supply contracts for newbuilds

MSC Meraviglia Class

RCCL Quantum Class

NCL Breakaway Class

Expedition Class

RCCL Harmony Class

Genting Dream Class

CCL Vista Class

Hapag Lloyd Expedition

TUI Mein Schiff Class

Viking Star Class

Silver Muse Class

Virgin Voyages Class

Costa Asia Class

Scanship on 13 cruise newbuild classes, representing total 46 newbuilds entering market from 2014, 18 vessels already entered market, with 28 ships remaining to be launched

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Advanced Wastewater Purification

The Scanship AWP system illustration for NCL Breakaway Class built at Meyer Werft in Papenburg, Germany.

Parameter:	Influent (mg/l):	Effluent (mg/l):	Reduction (%):	IMO 227 (64):
Total Nitrogen	162	15,4	90,3 %	20mg/l or 70%
Total Phosphorous	17,4	0,29	97,8 %	1,0mg/l or 80%
Total suspended solids	603	2,3	99,6 %	35
COD	2 311	45	98,0 %	125
cBOD5	829	1,1	99,9 %	25
Thermotolerant coliforms	N.A.	1,9 cfu /100 ml	-	100
pH	N.A.	6,4-6,9	-	6,0-8,5

Geometric mean according to MEPC 227(64)
44 inlet samples
44 outlet samples
10 days sampling

Results from Compliance Testing for Med F Certificate with all grey & black water including reject water from foodwaste processing and bio-residue dewatering and drying

- Cruise market leading solution for purifying black and grey water including galley water, reject from foodwaste and reject water from bio-residue treatment
- Efficient recovery of treated water with more than 98,5% recovered as clean effluent and less than 1,5% separated out as bio residue for dewatering and drying
- Flexible operations - multi streams or only black water – Alaska mode or Helcom mode
- Med B and Med F certificates for IMO Marpol MEPC 227(64) and chapter 4.2 including nitrogen and phosphorous removal
- Cost efficient operations from low energy consumption (<2.5kWh/m3) and process chemicals (<0,2USD/m3)
- Scanship's footprint with 85 Scanship AWP systems for black & grey water whereas:
  - 57 are in operation
  - 26 has been installed as turn-key retrofits
  - 31 installed in the newbuild market in the passed
  - 28 are being delivered to future newbuilds (in backlog)
- 41% are compliant with Alaska Murkowski Standard, 39% is compliant with MEPC 227(64) chapter 4.2 with TN & TP removal, and 20% are prepared for MEPC 227(64) chapter 4.2 with TN & TP

The Scanship AWP systems has become an cruise industry standard, and enabled ship-owners to meet the most strict environmental standards in the "maritime" world

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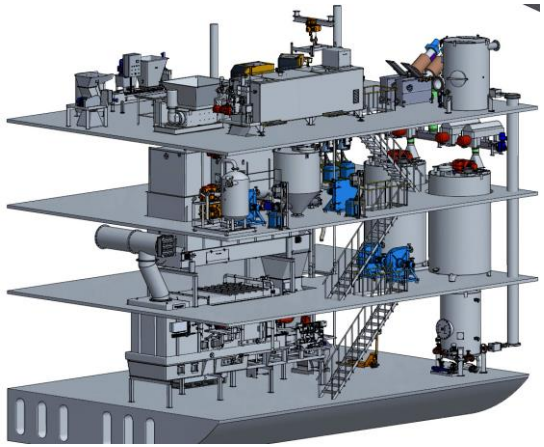
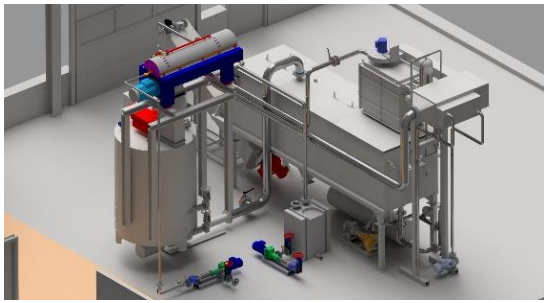
Waste management and bio-residue treatment



Total waste management system in 4 deck configuration



Bio-mass dewatering and drying systems for aquaculture fish farming industry

In the Cruise Market

- Vacuum foodwaste conveying system to eliminate overboard discharge and risk of contamination
- Bio-residue treatment of wastewater solids with dewatering and drying
- Food waste digester options in galleys to eliminate solid handling and logistics, with easy interface to Scanship AWP
- Incinerator system from 600kW up to 4,000kW exceeds IMO Marpol Annex V standard – new refractory lining to reduce maintenance and unique ash cooling system
- External steam dryers for 24/7 operations, zero discharge of bio residues using incinerators, and bagging options for landing
- Recycling equipment provides income opportunities from landing

In the Aquaculture Market

- Separated solids from the RAS with low concentrations of about 0,5% DM is pumped to the Scanship sludge treatment.
- The sludge from the decanters is processed in a Scanship batch dryer system, where the dry solids is increased to 85% DM before being bagged. It may be used for agricultural soil enhancement, heat and energy recovery, or as a valuable feedstock in other industrial applications.
- The volume reduction of the aquaculture sludge through the Scanship process is very efficient, reducing the residues down to about 0.5% of its original volume.

Interest for sustainable solutions in Cruise Business

CRUISE-NYKOMMER SATSER PÅ NORSK TEKNOLOGI

Kan åpne store vekstmuligheter for Lysaker-selskapet

Richard Branson velger Scanship

SHIPPING: **Scanship skal i samarbeid med cruiserederiet Virgin Voyages utvikle ny teknologi for energigjenvinning fra avfall. Potensialet er betydelig, ifølge Lysaker-selskapet.**

«Richard Branson Chooses Scanship»

From Genova, 1/11-2017

(Virgin has received the right to promote Scanship MAP (Microwave Assisted Pyrolysis) Technology for sustainable and environmental waste handling)

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Why Aquaculture?

- Growing marked
- We have the technology
- Urgent need for sustainable solutions

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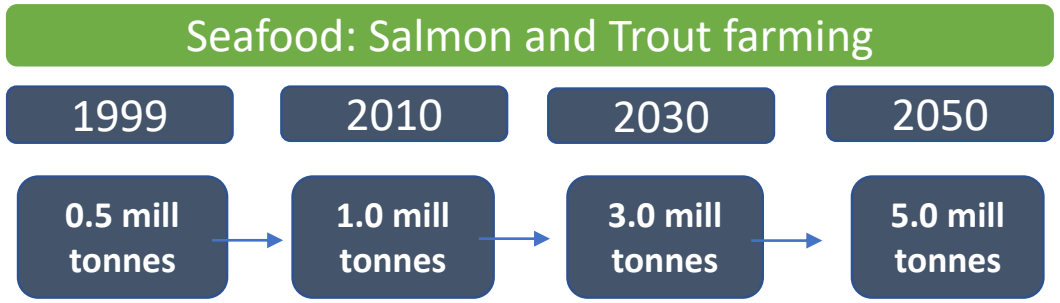
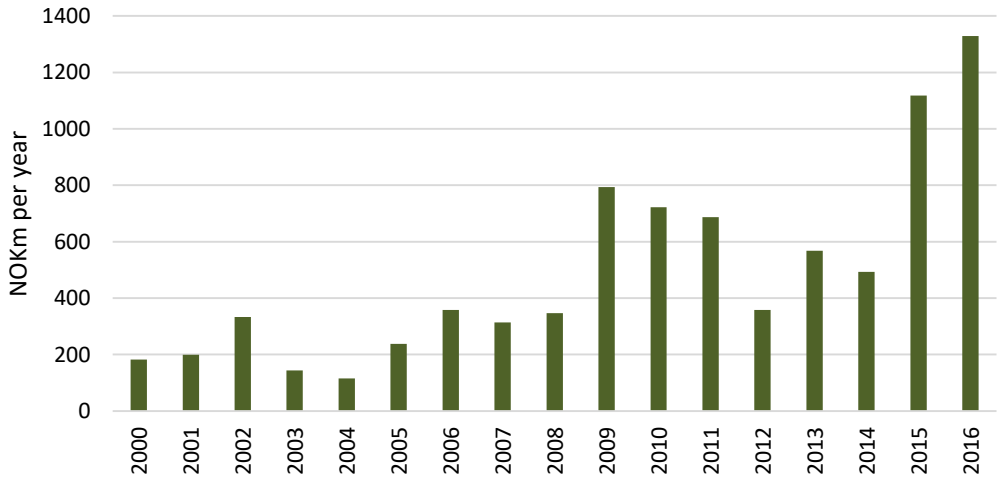
Aquaculture

High level goals for the Norwegian Salmon & Trout farming:



Source: Almås et al, 2013, «Verdiskapning basert på produktive hav i 2050»

Investments in smolt facilites (Norway, NOKm)



What does it take?

- Aim to grow Norwegian aquaculture production 2.7x and 4.7x towards 2030 and 2050, from todays level of around 1.2mill tonnes.

  = smolt capacity must follow

- Reliant on converting to larger-smolt sizes (from 120g -> 0.5/1kg). Post-smolt triggers larger facilities -> max 50kg per km3.
- Limited availability of new smolt licenses -> larger plants and upgrades of existing plants.
- Installation of RAS technology at existing and new plants. Currently only around 20-30% of the smolt providers have RAS technology.

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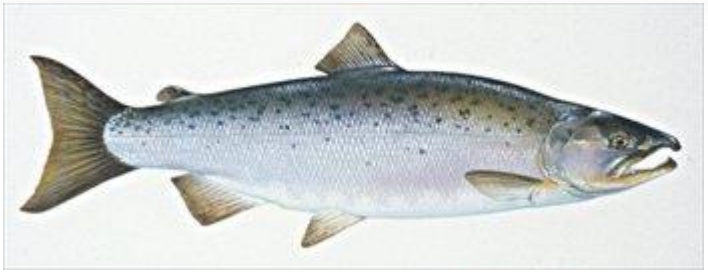
What is the situation today regarding sludge and excess nutrients from fish production?

Sludge Production estimated based on fish feed



Dissolved waste
Organic content (COD)
Carbon Dioxide (CO_2)
Nitrous gas (N_2)
Ammonium (NH_4+/NH_3)

Removal technique
Aeration
Kaldnes® MBBR

Solid waste
Feaces
Exess feed

Removal technique
Particle Removal –Drumfilter
Fine solids – UF/ozone

Sludge from MBBR

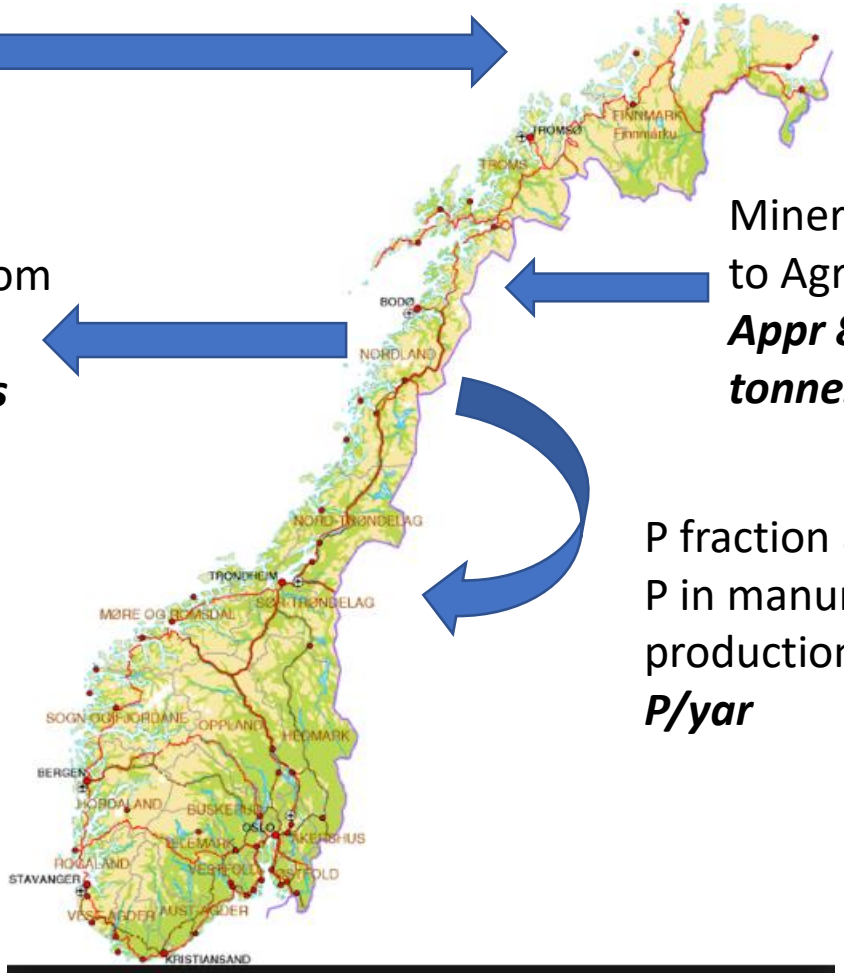
Sludge production estimate:
0,15-0,2 kg DM sludge/kg Feed

Based on feed the amount of sludge can be calculated to …..:

1,6 mill ton feed in 2016 and 0,15 – 0,2 kg DM/kg Feed equals >250.000 tonnes of DM/year

Some P numbers based on 2010 situation

Import P as fish feed:
Appr 9.000 tonnes P/year



P lost to the sea from fish production:
Appr. 9.000 tonnes P/year

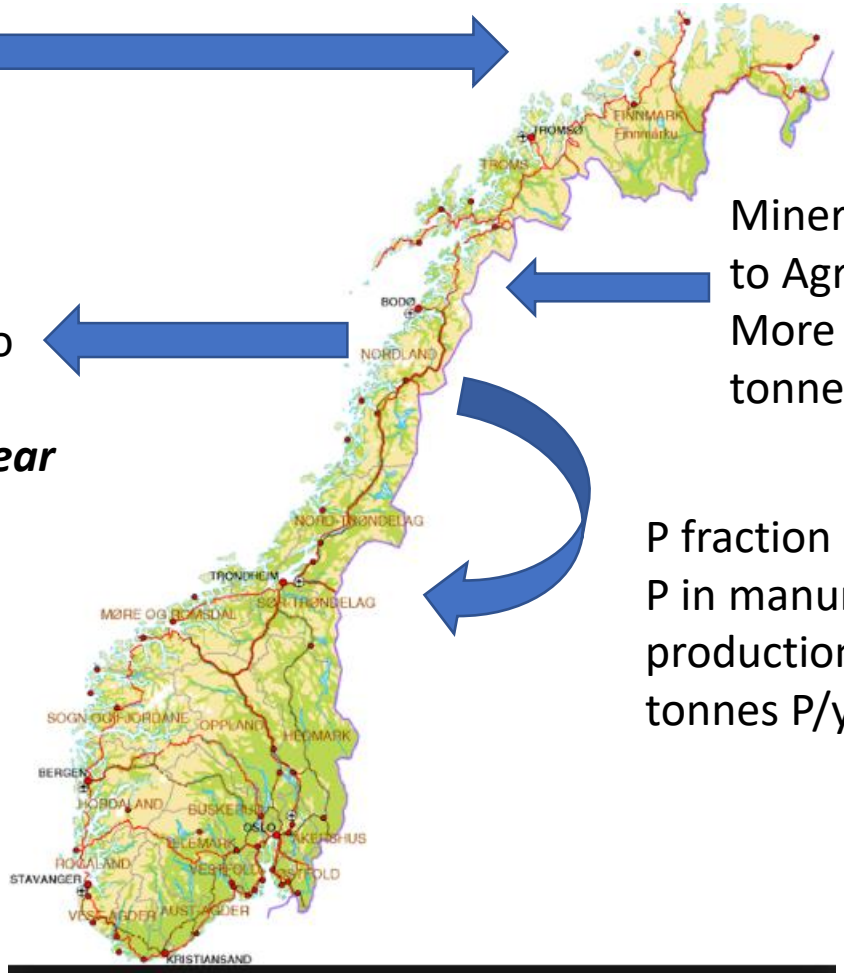
Mineral fertiliser to Agriculture:
Appr 8.000 tonnes P/year

P fraction available as seconday P in manure form animal production: ***12.000 tonnes P/yar***

Future scenario based on 2030, with same collection of P as per today

Import P as fish feed:
Appr 27.000 tonnes P/year

P Exported as fertiliser and less to the sea:
27.000 tonnes P/year



Mineral fertiliser to Agriculture: More than 8.000 tonnes P/year

P fraction available as seconday P in manure form animal production: more than 12.000 tonnes P/yar

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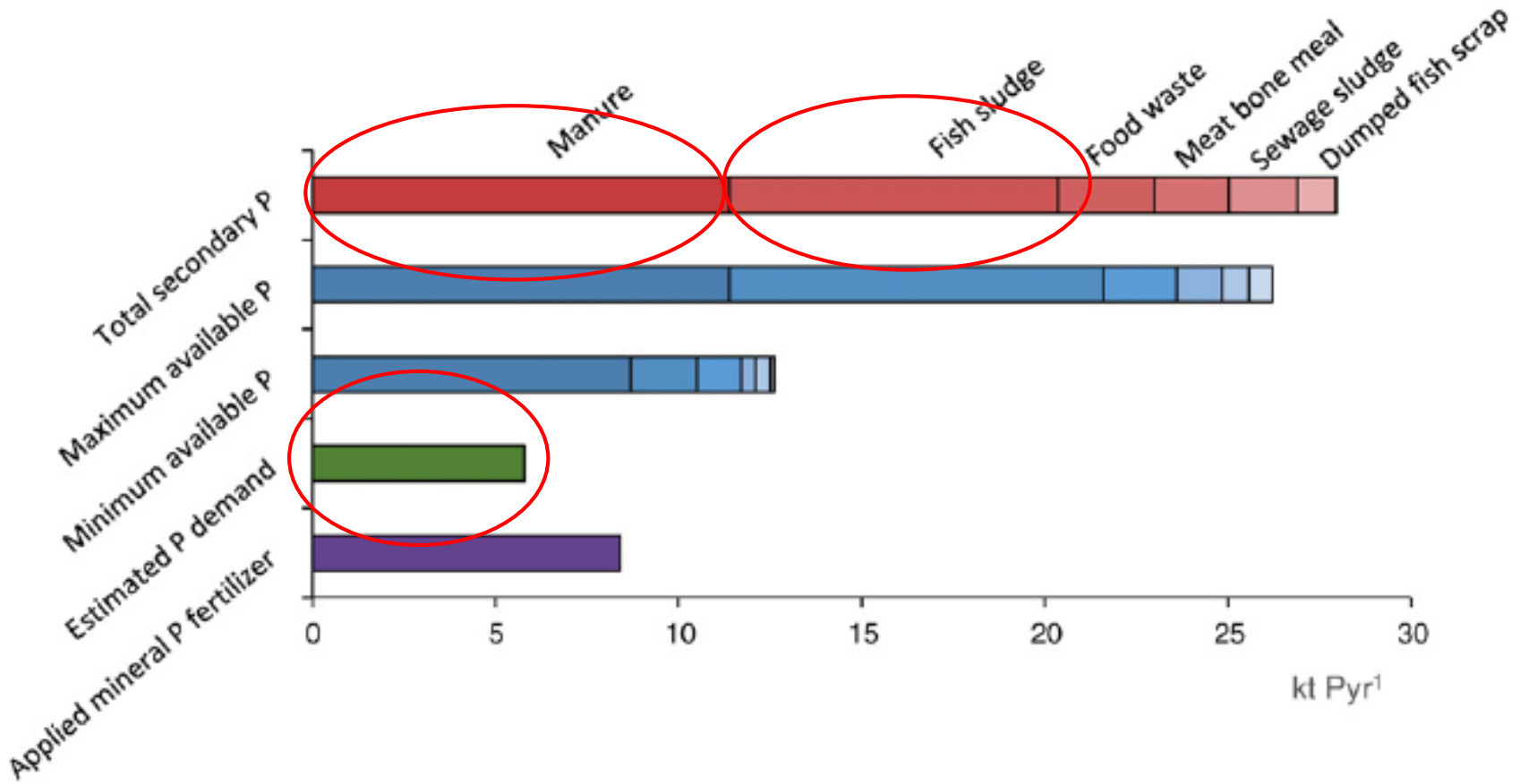
Avaliability of seconday P from varius sources compared with mineral P fertiliser



Some conclusions regarding fish sludge

«Norwegian fish sludge as fertiliser export…»

Article concludes that dried fish sludge can be the solution for loss of nutrients (N) from fish production by overcoming the handling and transport cost.

28 Debatt

Norsk fiskeslam til gjødseleksport

Tap av næringsstoffer til fjordene gjør oppdrettsnæringen lite bærekraftig. Næringstapet reduseres ved bruk av tørket fiskeslam som gjødsel.

Innlegg
Eva Brod og Tore Krogstad

Forskningen

To be concluded:

Large amount of nutrients will go directly to the sea if fish sludge continue to be handled like today.

Imported P for fish feed and lost P from fish production is in the same order of magnitude.

The need for P fertiliser in agriculture in Norway is limited, and other areas for recycling is needed

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The biggest concern right now is the land based fish production and the fjord areas

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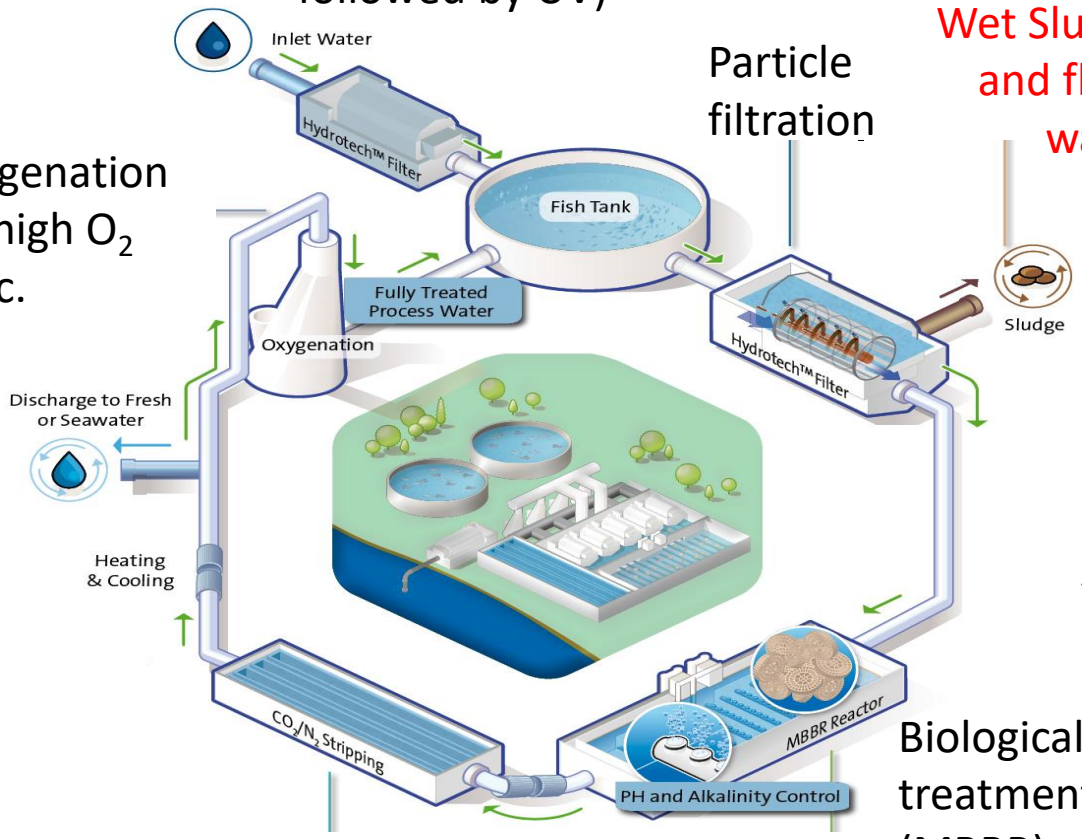
Example of a RAS system (Recirculating Aquaculture System)

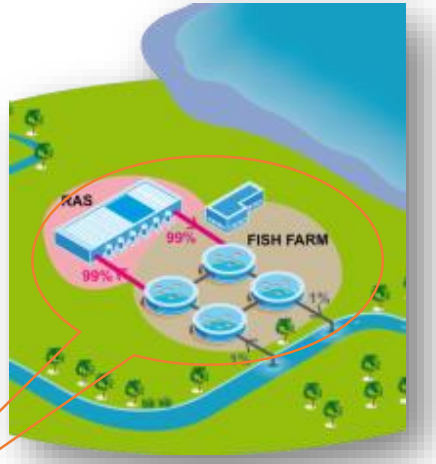
Pre filtration(often followed by UV)

Particle filtration

Wet Sludge and flush water

Oxygenation for high O_2 conc.





Temperature adjustment.
(Heat recovery from sludge drying)

Biological treatment (MBBR)

Degassing of N_2 and CO_2

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What is the contribution from Scanship?

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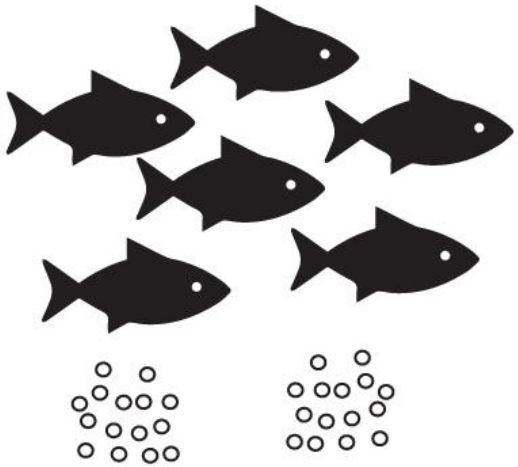
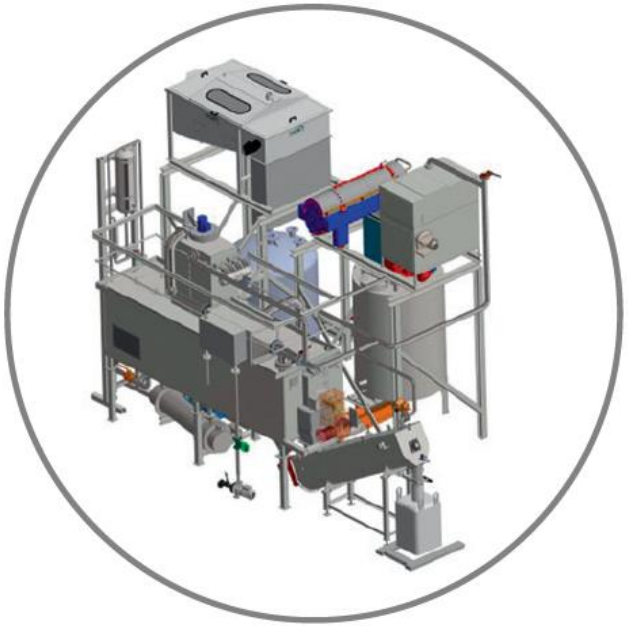
Scanship - Aquculture Sludge handling

Fish-Hatchery
and RAS-system





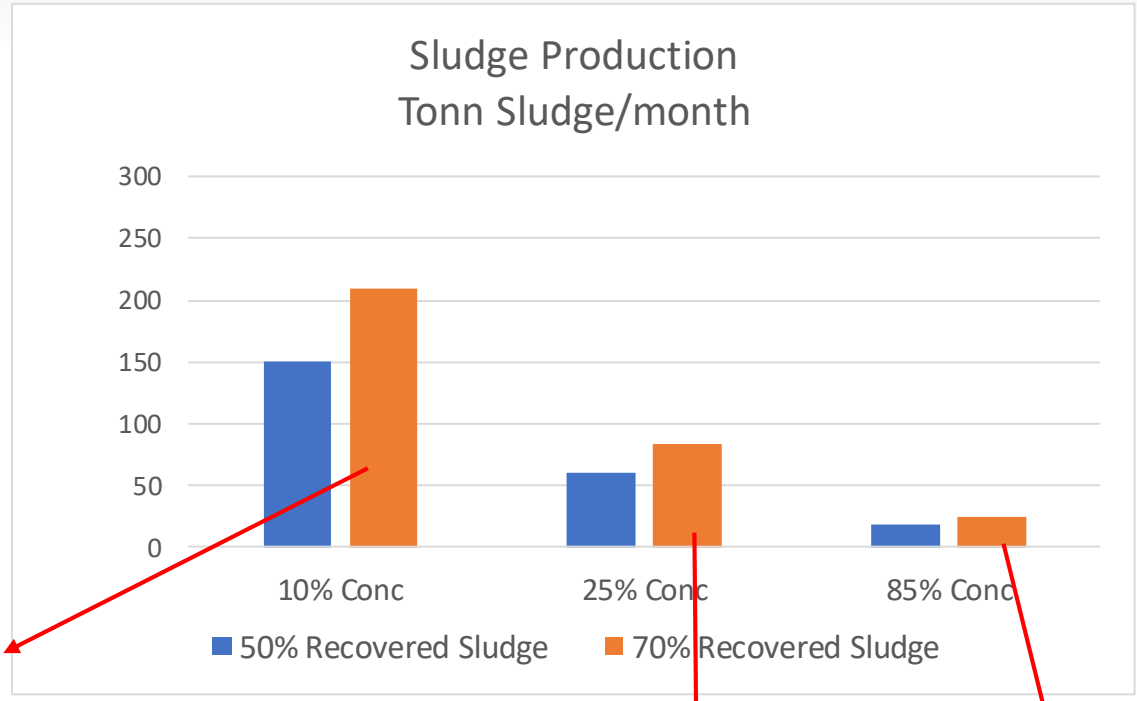
Dewatering and drying

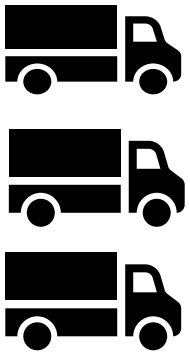
Biogass/Energy Plant

BioFuel for Industry

Fertiliser for Agri culture

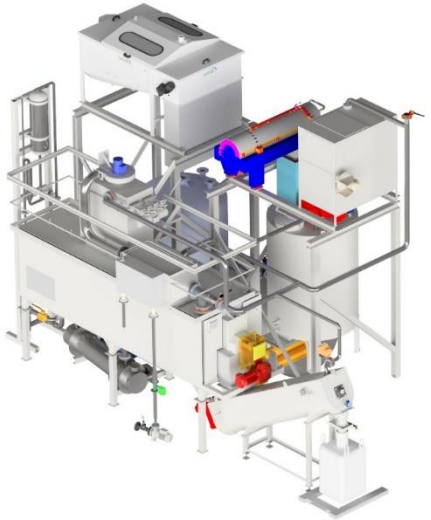
Value of Concentrating the sludge





25 ton/truck

Fish Plant:
5.000 kg feed/day



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Scanship 3 step dewatering and drying in order to have compact units and control of effluent

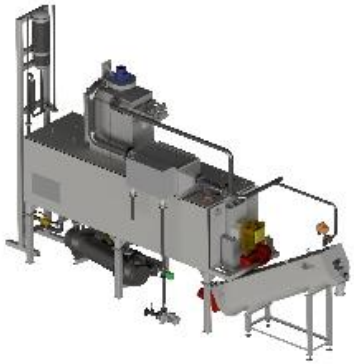
SLUDGE
0,1% DM

100 – 250 mgSS/l
between 5 – 15% of Total SS

10%
DM

1000 – 2000 mgSS/l
between 1 – 1,5% of Total SS

25%
DM



< 0,1% of Total SS

90%
DM

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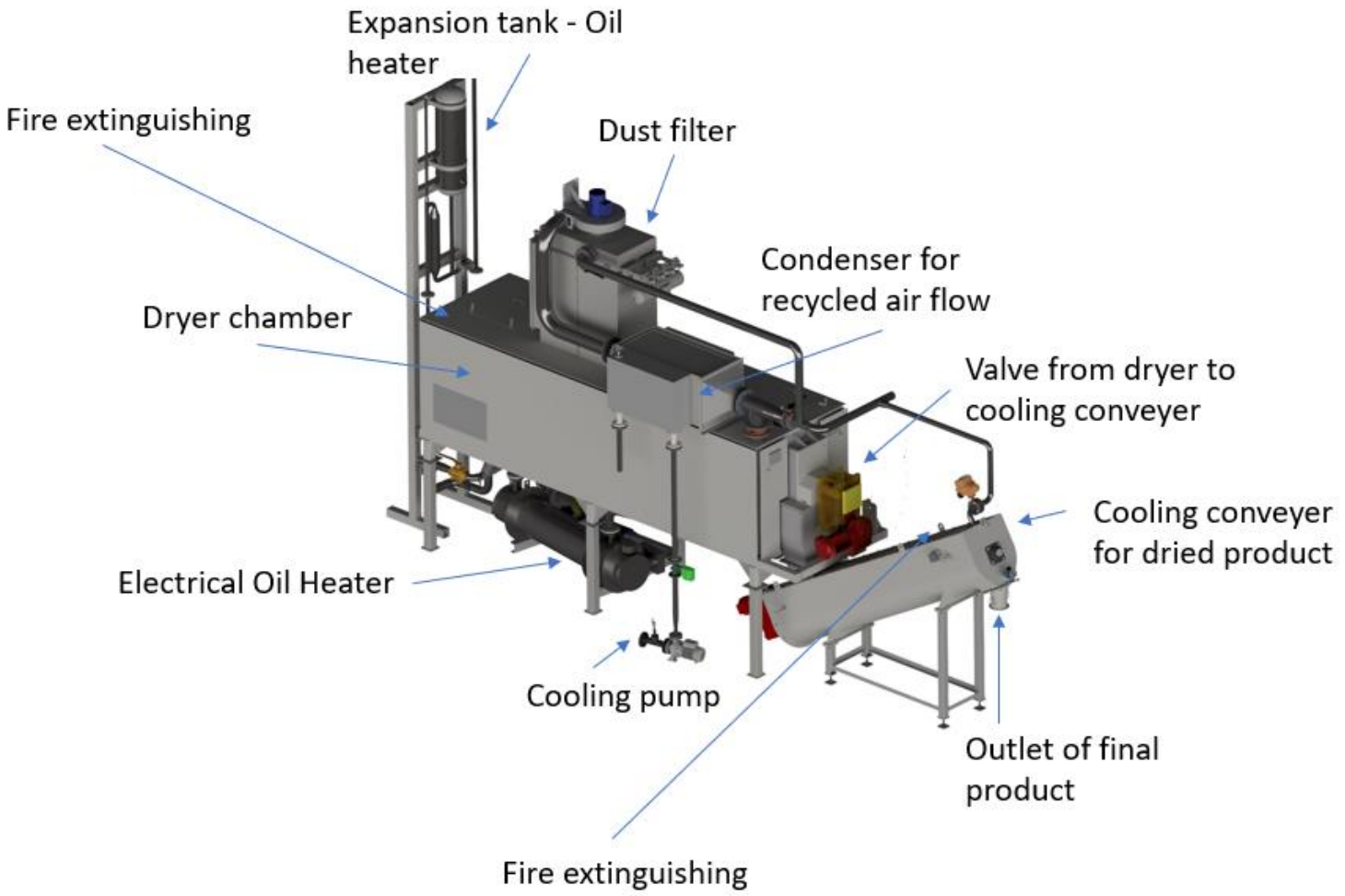
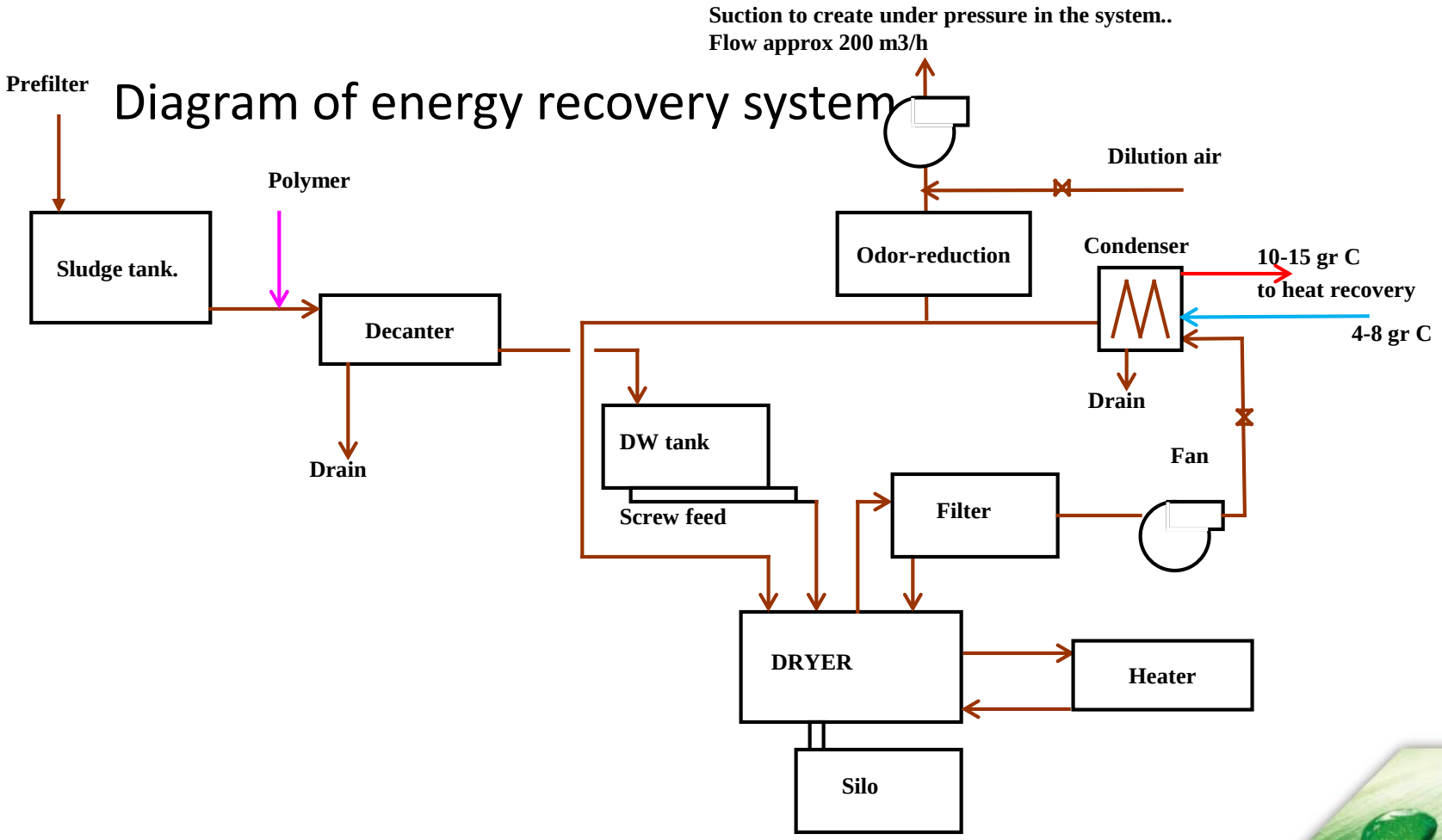
Scanship Dryer



Closed loop dryer system



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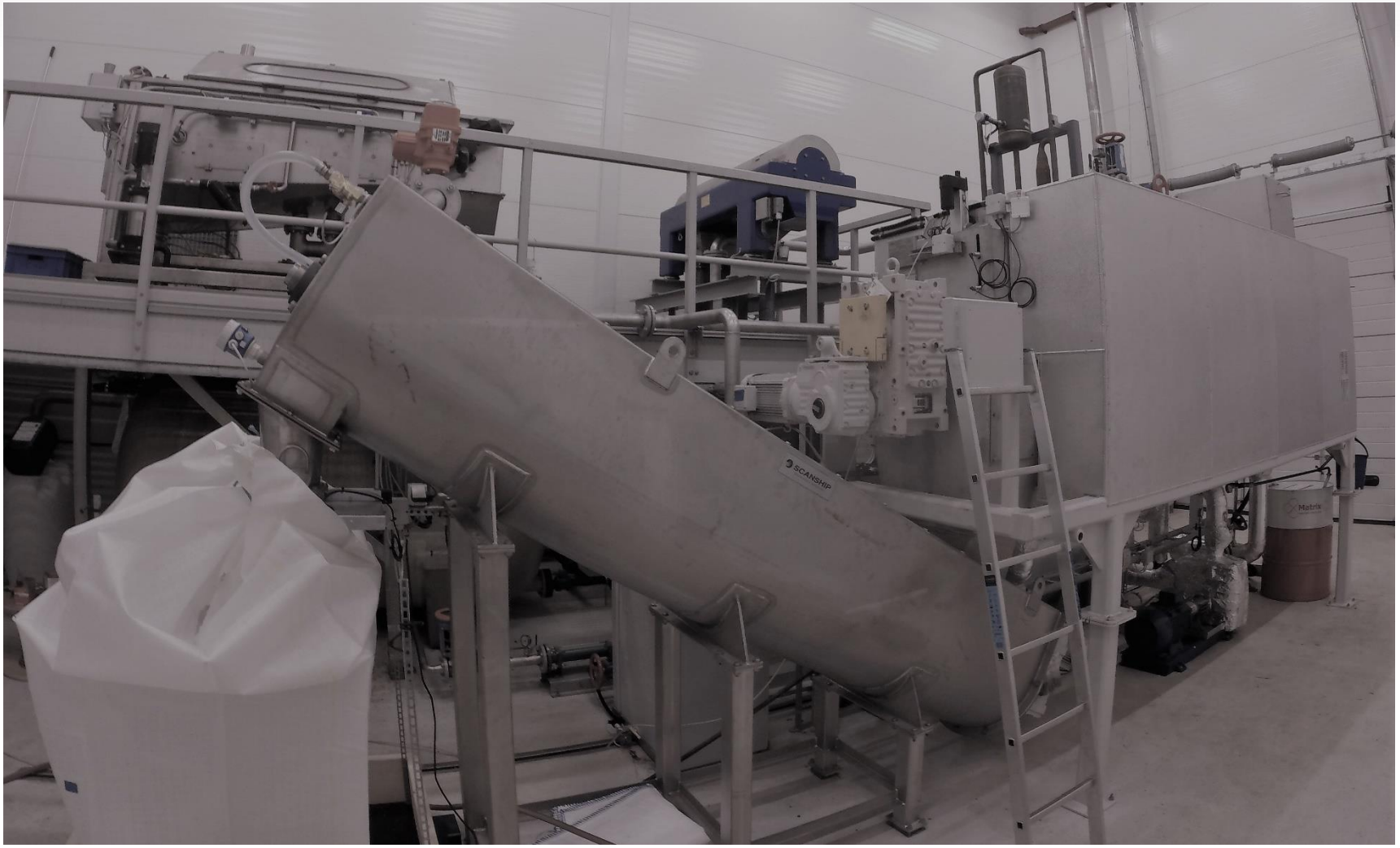
Reference Plant - Steinsvik



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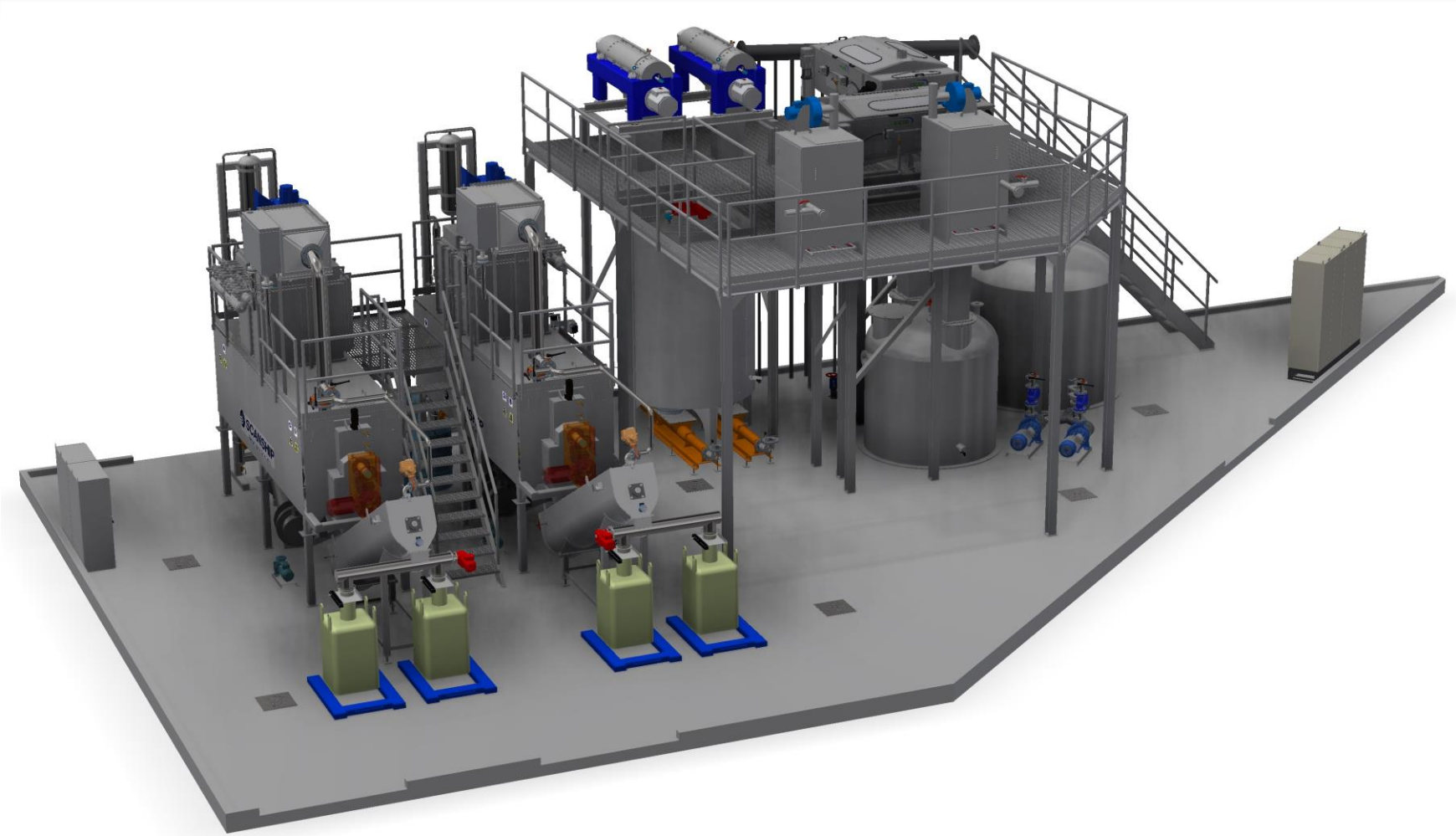
Reference - Sjøtroll



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What to do with the dry fish sludge?

- Biogas
- Fertiliser
- Biofuel – (not evaluated in this presetantion)

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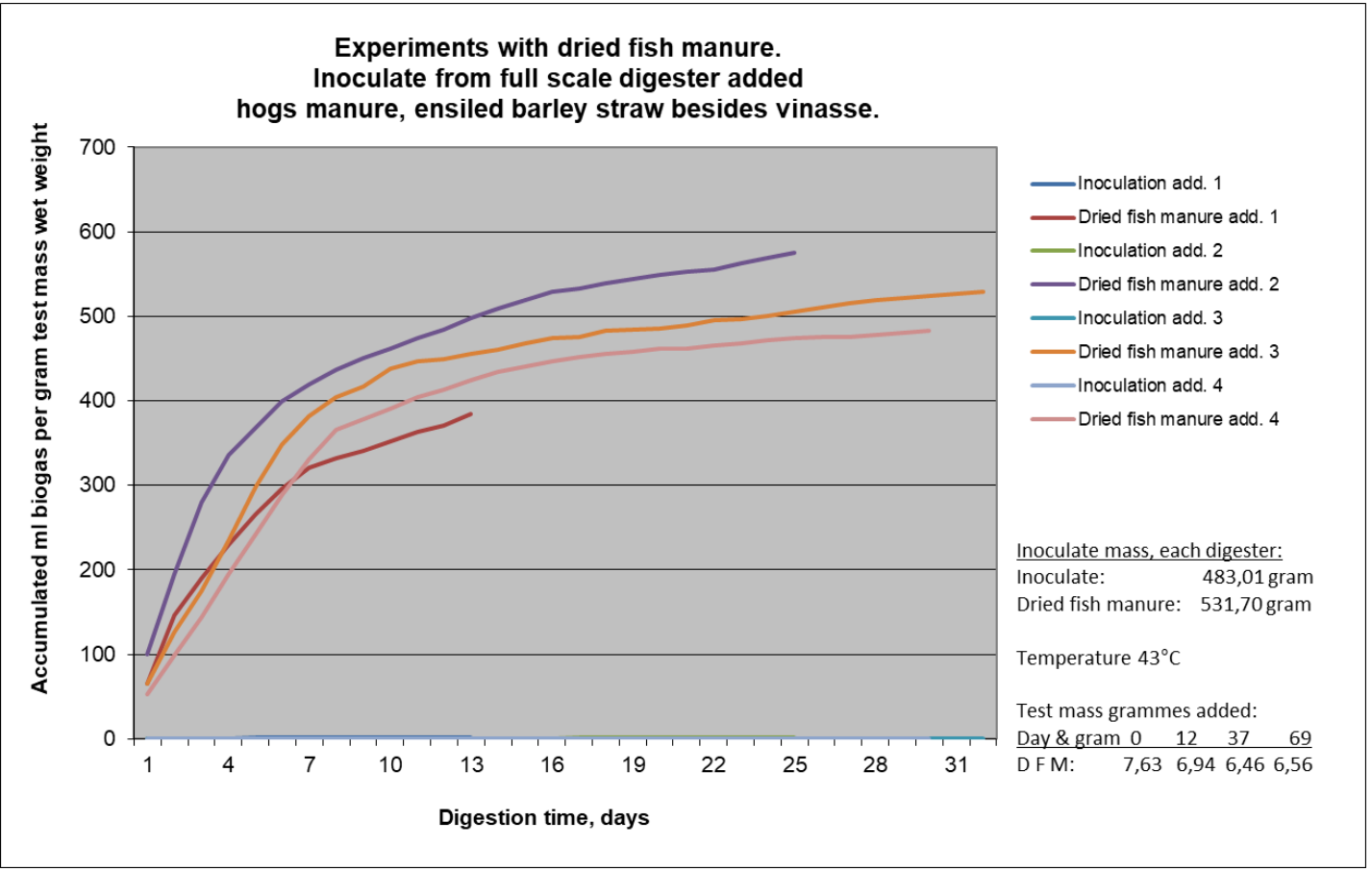
Biogas potential in dried fish sludge



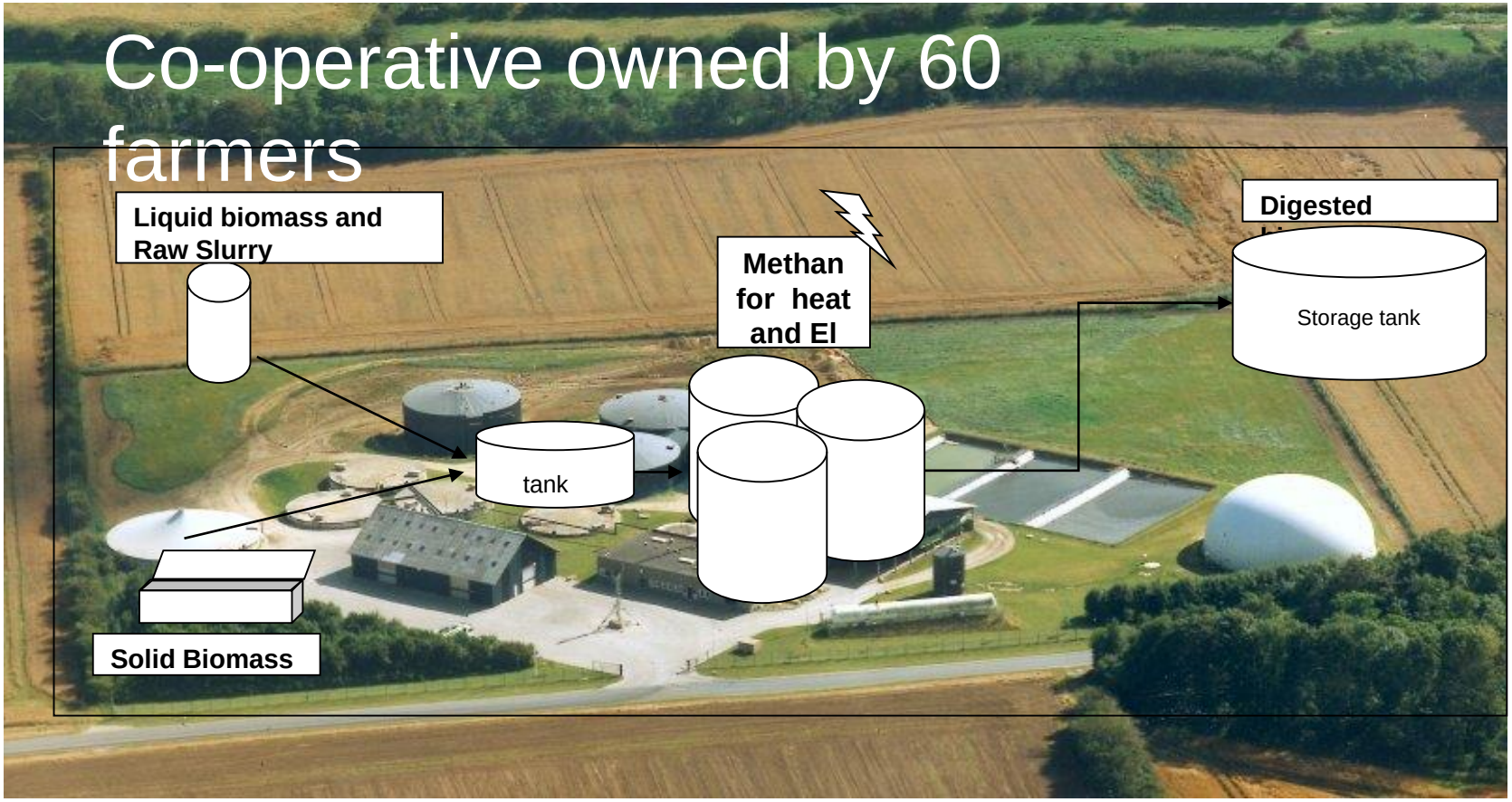
Calorific value:
15 MJ/kg, or 4,17 kWh/kg dry sludge

Result in test:
65-70% VS conversion

450-500 m^3 biogas/ton dry sludge

300 m^3 CH_4/ton dry sludge

Linkogas Amba



Value of Dried fish sludge, delivered to Danish Biogas Plants:
500 DDK/ton = € 67/ton

Tranport cost from Norway
€ 60-70/ton

Additional N and P has no value, even though digestate is used as fertiliser!

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Comparing fish sludge and municipal sludge

		Fish Sludge[1)]	Fish Sludge Dried[1)]	Fish Sludge Dried[2)] (Scanship)	Municipal sludge[3)] (Bergen)	Dried Digested Municipal sludge[4)]	Fish Sludge Dried[5)] (Steinsvik)
DM	g/100 g DM	13	95	94	4,7	89,6	87,5
OM	g/100 g DM	79	88	80	73	53,6	78
pH		5,8	5,5	5,6	-	8,2	-
N-total	g/kg DM	82	71	58	46	34	-
P-Total	g/kg DM	24	14	20	14	22	30
K	g/kg DM	8,2	0,27	0,94	2,2	0,7	1
Ca	g/kg DM	42	28	43	7,8	14	65
Cd	mg/kg DM	0,77	0,26	-	0,45	0,68	<1,5
Pb	mg/kg DM	0,59	0,17	-	35	13,3	1,8
Hg	mg/kg DM	0,038	0,038	-	0,2	0,5	-
Ni	mg/kg DM	1,2	0,6	-	<20	11,1	<15
Zn	mg/kg DM	410	430	260	370	361	624
Cu	mg/kg DM	22	17	9,2	170	234	15
Cr	mg/kg DM	4,8	4,2	-	14	17	31

Comparing Municipal Sludge and Fish Sludge

Fish sludge

- More Nitrogen, especially if municipal sludge has been digested
- Different content of heavy metals
- High Ca if pH is adjusted with lime
- High content of organic material
- The composition is more well-defined with less variations and less pollution
- More micro nutrients, less addition in order to have full fertiliser

Municipal sludge

- Municipal sludge is considered as a waste and cost for handling sludge as a waste is accepted by the tax payers
- The unpredictable pollution from industry and household chemicals will always be a disadvantage for Municipal sludge as a fertiliser

Partnership for sustainable handling of residues from fish farms

The value of dried fish sludge is depending on where it is utilized

Transport of the sludge to where it can be recycled is making it difficult to have positive economy

In Norway the reception of the sludge often include gate fee
(If It will be compared to organic waste product)

Partnership for sustainable handling of residues from fish farms

- **Scanship** deliver stable dried sludge as a by-product from fish farming
- **Skretting** as feed supplier offers return transport of dried sludge, when they deliver feed (with own logistic)
- **HØST** design and market the fertiliser-mix, based on dried fish sludge.
- **IVAR** is producer of the MINORGA® product and back upp with biogas plants if needed.

Transport of Fish Feed along the Norwegian Cost

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SKRETTING
a Nutreco company

Cover the whole coast line

Den nye fabrikken har en grunnflate på ca. 600 m2.

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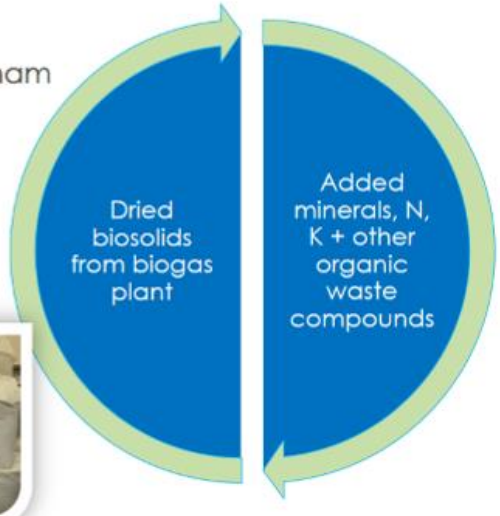
Minorga® fertilizer products

- For agriculture use, as alternative to mineral fertilizers
- Uniqe in Europe
- Sales in Norway and export to Vietnam



Main products MINORGA® 10-2-5, MINORGA® 12-1-0 and MINORGA® 5-1-9 for the Norwegian market (cereal production)

MINORGA® 10-3-14, MINORGA® 10-3-6, MINORGA® 5-3-11 and MINORGA® 7-3-8 designed for the export market (tropical agriculture)

I·V·A·R HØST

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		BAG 1	BAG 2	BAG 3			
Tørrstoff	%	93,9	93,3	87,5	91,6	3,2 %	en BAG under 90 %
Glødetap	% TS	81,4	65,4	74,6	73,8	8,9 %	Varierer noe, men innenfor 10 %
Ledningsevne	mS/m	756	757	797	770,0	2,5 %	OK
pH		5,3	5,6	5,6	5,5	2,6 %	OK
As	mg*kg TS^{-1}	0,6	< 0,3	< 0,3	0,6	0,0 %	OK
Cd	mg*kg TS^{-1}	1,5	1,3	0,87	1,2	21,5 %	Ser kontrollert ut
Cr	mg*kg TS^{-1}	16	12	15	14,3	11,9 %	OK
Cu	mg*kg TS^{-1}	28	27	19	24,7	16,3 %	OK
Hg	mg*kg TS^{-1}	0,08	0,06	0,05	0,1	19,7 %	OK
Ni	mg*kg TS^{-1}	7,9	8,3	4	6,7	28,8 %	OK
Pb	mg*kg TS^{-1}	3	4	4	3,7	12,9 %	OK
Zn	mg*kg TS^{-1}	560	420	220	400,0	34,9 %	Ser kontrollert ut
N-Kjeldahl	g * 100 g TS^{-1}	6,77	6,88	8,43	7,4	10,3 %	Veldig næringsrikt
NH_4-N	g * 100 g TS^{-1}	0,199	0,184	0,316	0,2	25,3 %	Variere med TS
		2,9 %	2,7 %	3,7 %			rundt 3 %
NO_3-N	g * 100 g TS^{-1}	0	0	0	0,0		Nitrat ikke forventet
P-Total	g * 100 g TS^{-1}	2,83	3,24	2,71	2,9	7,8 %	HØYT P nivå

By using dried fish sludge in the fertiliser production you can argue that it has become a competitive ingredients to Municipal sludge in the Minorga® fertiliser

By using the relation between HØST and Vietnam it is possible to compete world wide… and export excess nutrients from Norwegian fish production to grow new crops for feed

Thank you for your attention