A new approach to energy-efficient treatment of wastewater produced by the fish industry in Vietnam

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Introduction

In the last few years, South-East Asia has experienced strong economic growth leading to an increasing number of industrial zones and higher demand for energy. The growth rate of the energy consumption is more than 11 % p.a. in Vietnam only. Along with the higher energy consumption, increasing industrial production has a severe environmental impact (pollution of water bodies, greenhouse gas emissions). In a joint-project funded by the Federal Ministry of Education and Research (BMBF) called AKIZ, a system for the treatment of wastewater from fish and seafood processing industry is to be developed and evaluated.

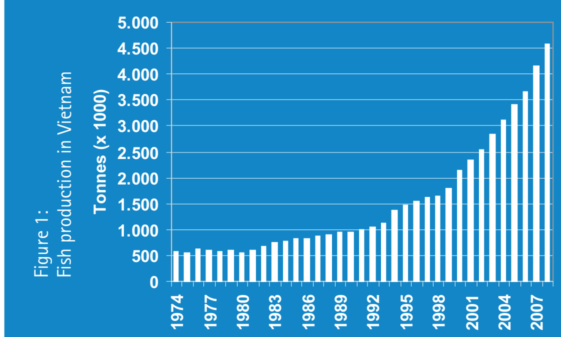


Figure 1: Fish production in Vietnam

The fish processing industry is the third large industry in Vietnam and experiences enormous growth in the last years, as shown in fig 1. In 2008 the total processed raw fish was more than 4.5 mil tons. Most of it pangasius that is exported to the USA and EU markets.

Material

Table 1: Waste water characteristic from a fish processing factory in the Mekong Delta, Vietnam

	COD	BOD	TN	SS	pH	T
Conc.	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(-)	(°c)
	833	615	540	110	6.7	28-33
Spec. Load	(kg/mt)	(kg/mt)	(kg/mt)	(kg/mt)		
(5 m³/mt)	4.1	3.1	2.7	0.6		

The data in shown in table 1 relate to a production of approx 40 mt/d of Pangasius filet. That represents 120 mt/d relative to raw fish processing, this being responsible for 492 kg/d of COD and 324 kg/d of the TN load in the waste water stream of 600 m³/d. The Water consumption is 5 m³/mt of raw fish.

In the fish-processing industry a lot of process steps are executed depending on the end-product. Fish production for human use includes mainly skinning, washing and filleting, besides transportation, weighing and other operations. Most of the wastewater is produced in washing processes. As the material is of organic origin, the wastewater is mainly polluted with lipids and proteins. Depending on the raw material and the end-product, the organic pollution can vary significantly between sites. Water usage efficiency is the main reason for variety in pollutant concentration.

Results

Table 2: Specific energy balance in kWh/mt raw fish

	Without DAF	With DAF
Consumption	4.3	4.1
Production	6.8	4.7
Recovery	2.5	0.6

The energy consumption and production values calculated for the proposed combined treatment system are shown in Table 3. The utilization of DAF unit leads to a smaller C/N ratio in the wastewater stream. This reduces energy recovery through biogas, while energy consumption for nitrogen removal doesn't decrease by the same amount.

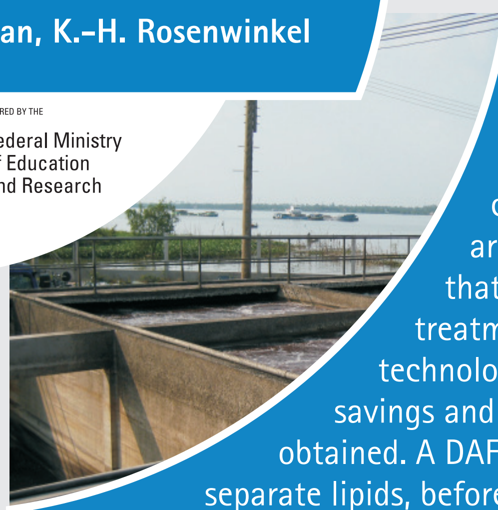
Table 3: Energy balance based on removal rates of the coupled system (variant based on DAF in brackets)

	Unit	DAF	Anaerobic C elimination	Anoxic zone	Partial nitritation	Anamox	Overall performance	
COD removal*	[%]	(30)	80 (56)	18 (12)	-		98 (98)	
N removal	[%]	(15)	-	5 (3.5)	-	86 (75)	91 (93,5)	
Biogas generation	kWh/d	-	1394 (976)	-	-	-	1394 (976)	
Heat production**	kWh/d	-	697 (488)	-	-	-	697 (488)	
Cooling energy production***	kWh/d	-	324 (226)	-	-	-	324 (226)	300 (68)
Electricity production**	kWh/d	-	488 (342)	-	-	-	488 (342)	
Energy consumption	kWh/d	(-60)	-72 (-72)	-20 (-20)	-400 (-337)	-20 (-20)	-512 (-500)	

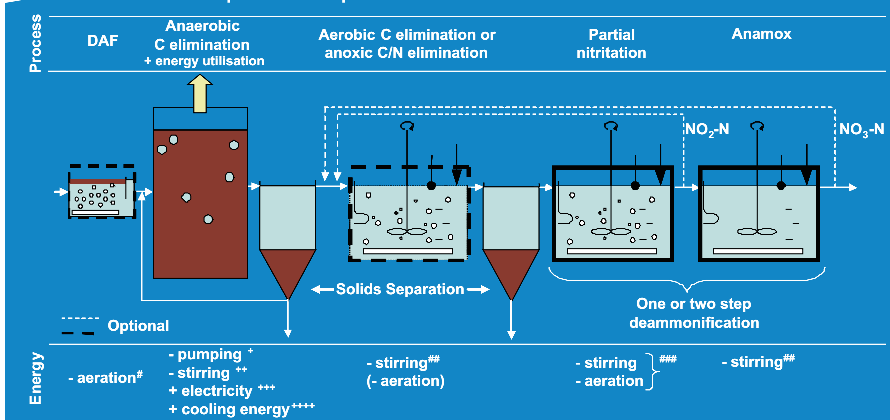
* 2 % non-biodegradable
** efficiency of co-generation unit: 35 % electricity, 50 % heat, *** electricity equivalent, efficiency of adsorption refrigerator: 65 % of heat, efficiency of compression refrigerator: 140 % of electricity.

For the shown example the combination of anaerobic treatment with an energy efficient nitrogen removal system, allows a positive energy balance to be attained for the overall treatment system (Tab. 2). Without pre-treatment by Dissolved Air Flotation (DAF), the energy recovery potential is even higher. The whole potential can only be utilised, when co-generation's off heat it used for cooling. Taking the expected growth of the Vietnamese economy and fish production industry into consideration, the energy input required for the treatment of fish-processing wastewater can be minimized, with the technology presented.

Concept



Anaerobic treatment technology for carbon removal and deammonification for nitrogen removal are two established processes that allow energy-efficient treatment. By combining these technologies, an optimum in energy savings and energy recovery can be obtained. A DAF might by necessary to separate lipids, before anaerobic treatment.



0.1 kWh/m³; ## 0,5 kWh/m³; ### 2 kWh/kg N
+ 0,005 kWh/m³/m; ++ 0,12 kWh/(m³/d); +++ 0,35*10 kWh/m³ CH4; ++++ 0,5*0,65*0,71*10 kWh/m³ CH4

Figure 2: Coupled nitrogen/carbon removal and energy recovery system

In the anaerobic treatment step, the energy potential of the wastewater stream can be used for biogas production, without considering the carbon demand of a downstream nitrogen elimination step. The deammonification process enables the anaerobic reactor to be operated in a fashion that is optimized for biogas generation. If there are any anaerobically non-degradable wastewater constituents - and also in the event of the anaerobic reactor being affected by failures in operation - it may be necessary to implement another carbon elimination step.