Modernization of a Swiss MBT-plant with the SCHUBIO®-Process

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Abstract

The only operating mechanical-biological Swiss treatment plant for municipal solid waste (MSW) and biowaste (KBA Hard) will be modernized and the SCHUBIO®-Process will be implemented for the first time on industrial scale. The project and the characteristics of the innovative process are presented in this paper. It is shown, that all output fractions from MSW as well as from biowaste are completely recyclable.

Keywords

SCHUBIO®-Process, Municipal Solid Waste, Biowaste, washing process, Schaffhausen, KBA Hard

1 Introduction

The SCHUBIO®-Process has been developed with a background of long-time experience from mechanical-biological waste management. The process is based on the WABIO-Process and related wet fermentation technologies as shown in Figure 1.

For the first time fermentation of municipal solid waste has been implemented in 1989 in Vaasa, Finland on industrial scale with the WABIO-Process.

The company Deutsche Babcock Anlagen (DBA) took over the WABIO-Process and erected in Bottrop, Germany the first fermentation plant for biowaste. After DBA merged with the company Steinmüller in 1999, the DBA-WABIO-Process was abandoned.

Since then EcoEnergy has developed and brought to the market a washing process based on the concept for mechanical treatment from the DBA-WABIO-Process. The SCHUBIO®-Process, formerly called NMT-Process, has been taken over by the company SCHU AG Schaffhauser Umwelttechnik in 2008.

Startup for the first plant on industrial scale is planned for 2010 in Schaffhausen, Switzerland.

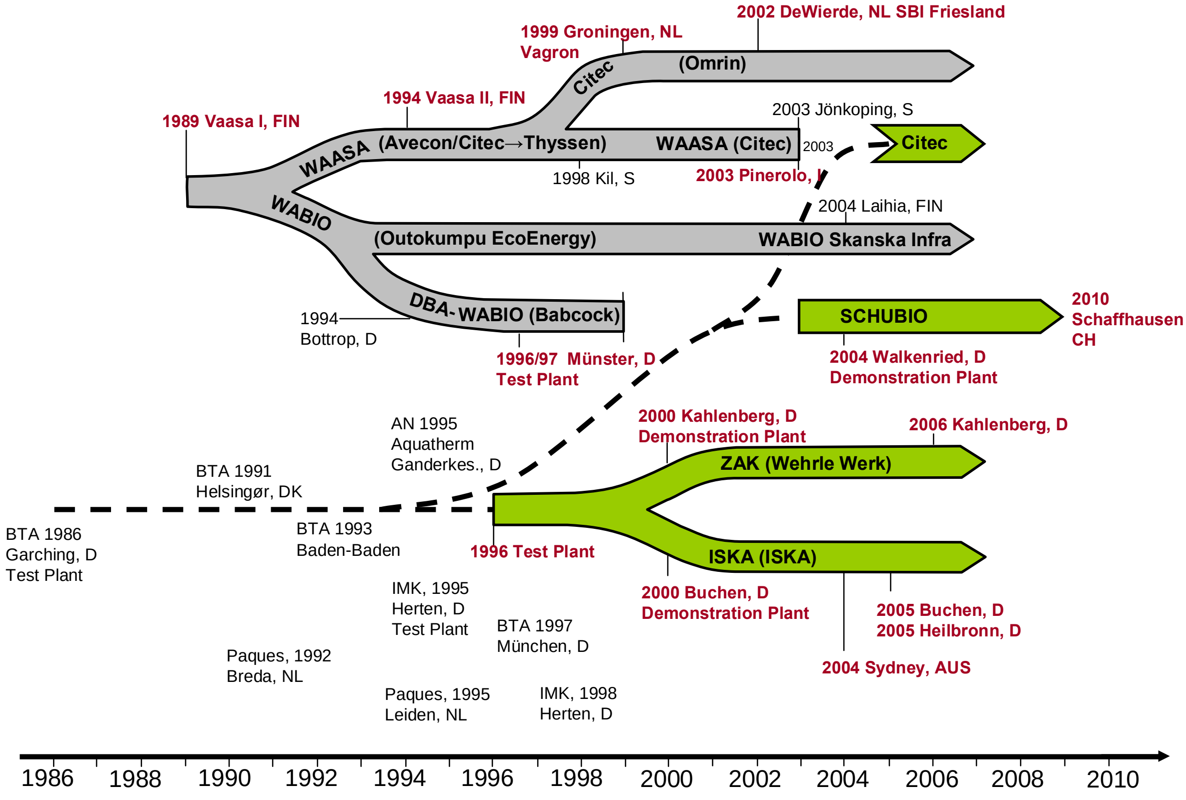

Figure 1: Development of Wash- and Percolation Technologies

The SCHUBIO®-Demonstration Plant is in operation since 2004 and has been operated with different input material. The Demonstration Plant was built with help from a grant by Deutsche Bundesstiftung Umwelt (DBU) (Table 1) and is still in operation.

Table 1: Development SCHUBIO®-Process

Year	**Development SCHUBIO-Process**
2000	Grant application to DBU
2004	Erection of Demonstration Plant and test runs in AWZ Wiefels, Germany
2005 - 2007	Pilot phase of the process at the EcoEnergy site in Walkenried, Germany
2008	Dimensioning tests, KBA Hard, Switzerland Take over of the process by SCHU AG Schaffhauser Umwelttechnik
2009	Planned start of construction Modernization KBA Hard, Switzerland

The Demonstration Plant is housed in a container and can be moved easily to different sites. Consequently, the design of the new KBA Hard could be verified by tests on site with the original input material (see Figure 2).

Figure 2: Different locations of the SCHUBIO®-Demonstration Plant

2 The SCHUBIO®-Process

The SCHUBIO®-Process can be applied for treatment of municipal solid waste as well as biowaste. First the material is pretreated by shredding and sieving at 100 mm as is common practice for MBT-technologies. The coarse fraction is baled and can be used for energy recovery. The fine fraction < 50 mm and 50 – 100 mm respectively is separated into inert fractions, organics fractions and a fluid fraction, containing dissolved matter, fine inert particles < 100 µm and organics < 1 mm. Water, heated to 40 °C, is used as separation agent and circulated in the process. Viscosity of the water is decreased by heating. Consequently the separation effect as well as efficiency of the dewatering is increasing.

The entire process yields surplus water even with municipal solid waste (MSW). The water retention potential of inert matter is minimal. Thus the inert fraction can be dewatered, down to a residual water content of < 5 %. The organic fraction can be dewatered to < 40 % water content due to several combined treatment steps. The separation of inert matter and the separation into fractions with different particle size are preconditions for the thermo-mechanical celllysis. The celllysis is causing the organic fibers to fray and separate, thus breaking down the cell walls so that cell water is released.

The inert fractions are rinsed, first with fresh water then with circulated water, and can be recycled as building material. If required further treatment in a demolition waste recycling plant yield even better quality. The following products are obtained from the waste:

- stones - gravel - sand - fine sand - silt.

The organic fractions are dewatered by screw presses after sieving. Dewatering includes also the cell water due to the thermo-mechanical celllysis as described above. Furthermore, the soluble, easily fermented biomass is transferred into the press water. Figure 3 shows the process flow diagram of the SCHUBIO®-Process for the KBA Hard with MSW and biowaste.

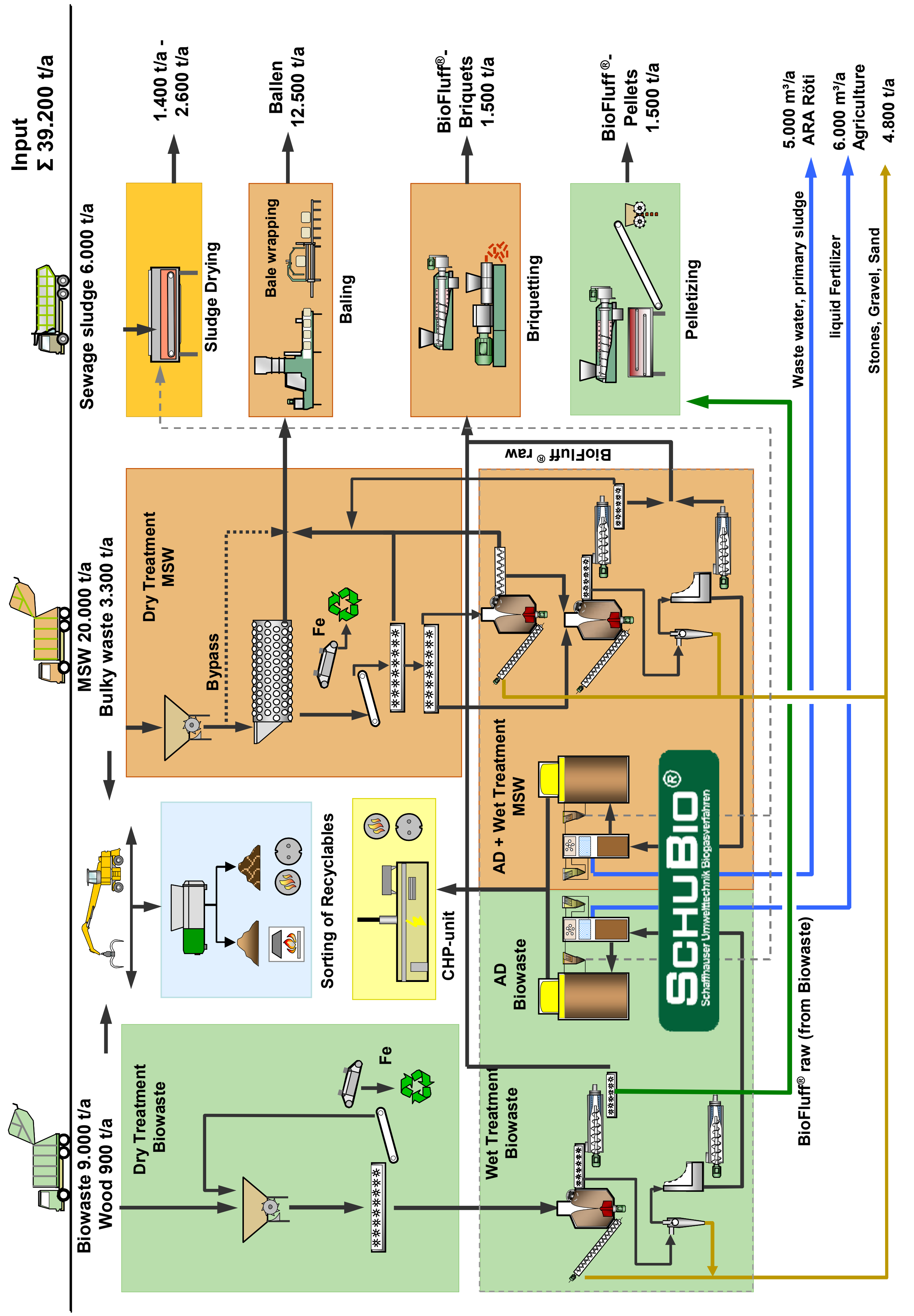

Figure 3: Process Flow Diagram KBA Hard with SCHUBIO®-Process

The pollutant content of the organic fractions (BioFluff®) is low, due to the process concept. The material contains also little chlorine because of the separation of plastics. Chlorine is present only as a soluble salt on a so called “background level”. The dewatering is achieved mechanically and not by drying so that all soluble pollutants are flushed out with the wash water and press water. Depending on the water cycle concept, 50 % to 90 % of pollutants are discharged, improving the quality of the BioFluff®.

Pressing of the organic fractions 2 and 3 is done at a temperature of > 70 °C for improving efficiency. Part of the heating energy comes from steam, produced with waste heat from the CHP- units and also from the press energy.

The Biomass has to be dried further for pelletizing. After drying the biomass is sieved at 15 mm and the still remaining plastics are discharged in the coarse fraction.

The fine fraction consists of nearly 100 % native biomass, the BioFluff®. The dried and sieved BioFluff® is conditioned according to the required recycling pathway. BioFluff® is a low polluted, dry stabilized biomass and is a versatile secondary raw material. The BioFluff® from MSW will be pressed to briquettes and used for thermal utilization.

In the SCHUBIO®-Process the easily biodegradable matter is transferred to the circulation water. The water contains organic matter up to a particle size of < 1 mm and is fed into an anaerobic digestion tank with biomass retention.

The chemical oxygen demand (COD)-degradation depends on the anaerobically degradable COD and reaches 85 % to 95 % degradation. Retention time is 5 to 10 days. Conventional biogas plants have a retention time of 18 to 21 days. The biogas is used to operate a CHP-unit. The generated power is fed onto the grid and the waste heat is used for drying sewage sludge and biomass from biowaste before pelletizing.

After digestion the waste water from the anaerobic digestion tank is treated in an aerobic reactor with biomass retention. The cleaned water is then reused as wash water for the SCHUBIO®-Process or discharged to a waste water treatment plant. The residual sludge form the anaerobic and aerobic process stage is the pollutant sink of the process.

3 Project Description

The MBT-plant KBA Hard in Beringen, Switzerland, has been built 35 years ago. The plant has been converted from a waste incineration plant and has been in operation as a MBT-plant for 20 years now. At the time the implemented composting technology was considered most innovative and has been known by the term “Schaffhauser Modell”.

Currently about 18.000 t/a MSW, 6.000 t/a Biowaste and about 6.000 t/a sewage sludge as well as 3.000 t/a bulky waste are treated in the plant.

At present, solids (MSW and industrial waste) are shreddered and sieved, yielding a dry, coarse fraction with high heating value and a wet fine fraction with lower heating value. The coarse fraction is baled and the bales are incinerated in the waste incineration plant KVA Buchs, either immediately or after intermediate storage at the KBA Hard site. The fine fraction is mixed with sewage sludge and composted in the rotting hall. After composting, the material is dried, stabilized and mass reduced and is likewise incinerated in the KVA Buchs. Biowaste is mechanically treated and composted separately.

The equipment has reached the end of its technical lifetime and must be replaced. Moreover, the new waste treatment technology should meet the requirements of better energy efficiency and preservation of resources.

The operating municipality, Kläranlageverband Schaffhausen, Neuhausen am Rheinfall, Feuerthalen und Flurlingen has therefore decided to modernize the KBA Hard by implementing the SCHUBIO®-Process. In the following figures the planned layout of the KBA Hard is shown:

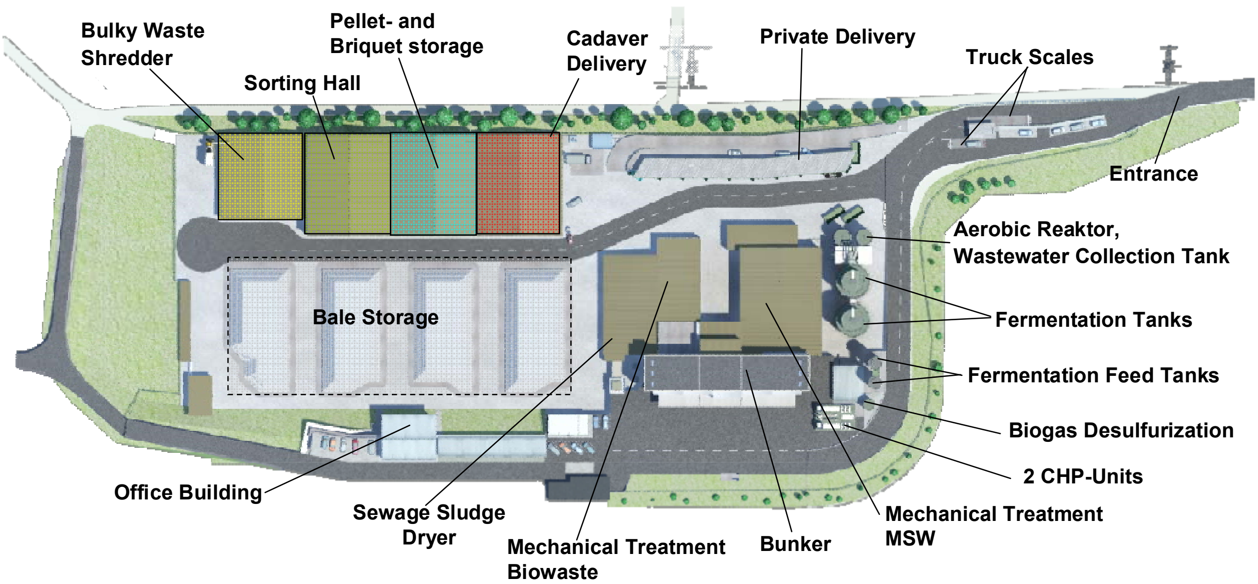

Figure 4: Modernization KBA Hard Top rview

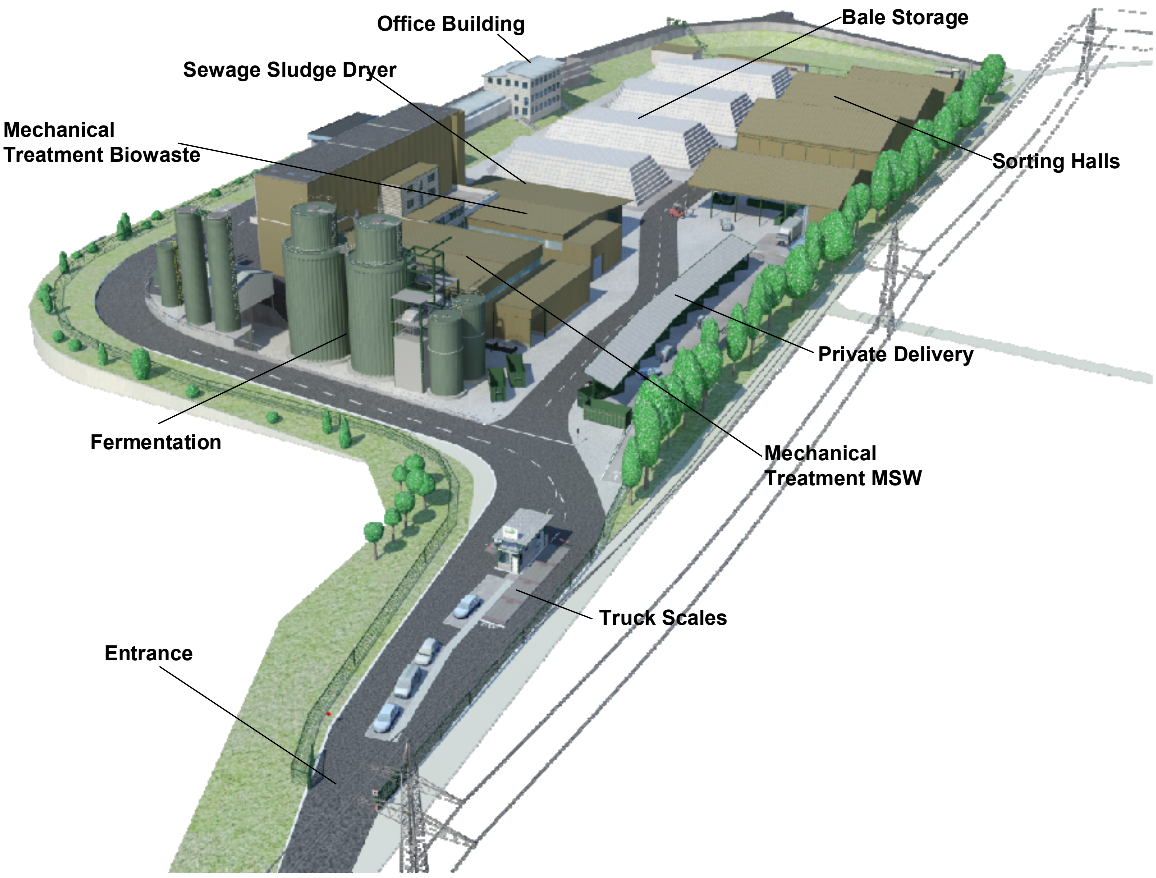

Figure 5: Modernization KBA Hard Overview

The new plant equipment will fit into the existing operation building. Only the fermentation tanks are located outside, as well as the two 450 kW CHP-units. The present rotting hall will be dismantled and the area will be used for bale storage. The logistics for private delivery will be improved and the shredder for bulky waste will be moved to an enclosed hall. The total investment is about 30 Million Swiss francs.

4 Sustainable Waste Separation

Explicit goal of the SCHUBIO®-Process is a complete recycling of the waste wherever possible. In the following we establish the recycling properties of the produced materials.

4.1 Biomass

4.1.1 Biomass from Biowaste

The organic fractions from biowaste are less polluted than most conventionally produced compost materials and meet the regulations for distribution of compost easily.

The following Table 2 shows the heavy metal content of the organic fractions (O1 ,O2, O3) compared to the input (Biowaste < 50 mm) and to the compost from the present KBA Hard as well as to the average of Swiss compost approved for horticulture. The data are also compared with the German and Swiss regulations for compost use.

A significant decrease of heavy metals is evident in the organic fractions. Exception is the chromium and nickel content of the fine fraction (O3) which is an artifact resulting from the test conditions. The phenomenon is common for demonstration plants, constructed from chromium nickel steel. Fine steel particles from abrasion and modification of the plant end up in the fine fractions.

Table 2: Heavy metals in the organic fractions from biowaste compared to biowaste-input and KBA Hard compost (average)

Parameter (mg/kg DM)	**Bio-waste < 50**	**Bio O 1**	**Bio O 2**	**Bio O 3**	**Compost KBA Hard**	**Swiss Compost Hort.**	**Stoff-VO (CH)**	**Bio-AbfVO (D)**
Lead (Pb)	21,0	16,0	11,6	15,8	47,5	69,7	120	150
Cadmium (Cd)	n.d.*	n.d.*	n.d.*	n.d.*	0,2	0,1	1	1,5
Chromium (Cr)	13,5	14,5	12,5	45,5	23,2	20,0	100	100
Copper (Cu)	30,5	18,0	9,5	17,3	56,8	58,4	100	100
Nickel (Ni)	9,5	8,5	6,3	22,8	16,3	15,8	30	50
Zinc (Zn)	94,5	57,0	95,0	94,0	215,3	155,4	400	400
Mercury (Hg)	0,1	n.d.**	n.d.**	n.d.**	0,1	n.d.	1	1

* Detection Limit 0,4 mg/kg DM ** Detection Limit 0,1 mg/kg DM

Already in 2000 the German Federal Environmental Agency (UBA) has proposed gradual limit values for fertilizers in soil with the objective to avoid long-term pollutant accumulation in the soil (UBA, 2002). Comparison shows that the organic fractions (O1, O2,-O3) meet even these soil-adapted limit values.

Table 3: Heavy metals in the organic fractions from biowaste compared to KBA Hard compost (average) and soil-adapted limit values

Parameter (mg/kg DM)	**Bio-waste < 50**	**Bio O 1**	**Bio O 2**	**Bio O 3**	**Compost KBA Hard**	**Proposal UBA 2000**		
						Clay	**Loam**	**Sand**
Lead (Pb)	21	16	11,6	15,8	47,5	71,75	50,45	29,15
Cadmium (Cd)	n.d.*	n.d.*	n.d.*	n.d.*	0,2	1,09	0,73	0,31
Chromium (Cr)	13,5	14,5	12,5	45,5	23,2	71,34	42,94	21,64
Copper (Cu)	30,5	18	9,5	17,3	56,8	46,72	32,52	18,32
Nickel (Ni)	9,5	8,5	6,3	22,8	16,3	50,62	36,42	11,57
Zinc (Zn)	94,5	57	95	94	215,3	173,71	138,21	74,31
Mercury (Hg)	0,1	n.d.**	n.d.**	n.d.**	0,1	0,72	0,37	0,08

* Detection Limit 0,4 mg/kg DM ** Detection Limit 0,1 mg/kg DM

The organics fractions (biomass) 2 and 3 are dispensed in the Schaffhausen region as peat substitute to hobby gardeners and nurseries. The organics 1 fraction will be used as biomass fuel.

4.1.2 Biomass from MSW

The biomass fractions from MSW (O 2 and O 3) show also a significant decrease of pollutants and meet the limit values for compost as well.

The following tableTable 4 shows the heavy metal content of the organic fractions compared to the input (MSW < 50 mm) and to the compost from the present KBA Hard as well as to the average of Swiss compost approved for horticulture. The data are also compared with the German and Swiss regulations.

Table 4: Heavy metals in the organic fractions from MSW compared to MSW-input and KBA Hard compost (average)

Parameter (mg/kg DM)	MSW Input < 50	MSW O 2	MSW O 3	Compost KBA Hard	Swiss Compost Hort.	Stoff-VO (CH)	Bio-AbfVO (D)
Lead (Pb)	190,0	62,8	57,0	47,5	69,7	120	150
Cadmium (Cd)	n.d.*	n.d.*	n.d.*	0,2	0,1	1	1,5
Chromium (Cr)	38,0	46,8	36,0	23,2	20,0	100	100
Copper (Cu)	111,0	75,9	45,5	56,8	58,4	100	100
Nickel (Ni)	24,5	19,0	17,5	16,3	15,8	30	50
Zinc (Zn)	400,0	227,5	130,5	215,3	155,4	400	400
Mercury (Hg)	0,4	0,1	0,2	0,1	n.d.	1	1

*Detection Limit 0,4 mg/kg DM

Nevertheless, application of the organic fractions from MSW in agriculture is still excluded because of the origin from MSW. For the current project the material will be used as low polluted fuel in cement kilns. The required fuel criteria in the cement industry are comparable with criteria for co-combustion in a coal fired power plant.

To evaluate the properties of the organic fractions from the SCHUBIO®-Process the following tableTable 5 shows the requirements for RDF (formulated by the German "Bundesgütegemeinschaft Sekundärbrennstoffe" (BGS) and the requirements of a coal fired power plant for co-combustion of RDF in comparison with the organic fractions.

Table 5: Heavy metal content of organic fraction from the SCHUBIO®-Process compared to RDF requirements from BGS and a coal fired power plant

Parameter in mg/kg DM	**BGS**	**Coal power plant**	**MSW-O 1**	**MSW-O 2**	**MSW-O 3**	**Bio O 1**	**Bio O 2**	**Bio O 3**
Arsenic (As)	5	5	n.d.*	n.d.	n.d.	n.d.	n.d.	n.d.
Lead (Pb)	190	70	84	61,3	58,8	16	13,3	16,2
Cadmium (Cd)	4	0,4	9,0	n.d.	n.d.	n.d.	n.d.	n.d.
Chromium (Cr)	125	125	94,5	39	36,3	14,5	13,2	45,3
Copper (Cu)	350	120	41,5	94,6	45,7	18	9	16,7
Nickel (Ni)	80	80	31,5	21,7	17,5	8,5	6,4	22,5
Mercury (Hg)	0,6	0,6	6,3	0,14	0,2	n.d.	n.d.	n.d.
Antimony (Sb)	25	25	-	140	n.d.	n.d.	n.d.	n.d.
Tin (Sn)	30	60	23	24	28	n.d.	n.d.	n.d.
Thallium (Tl)	1	1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cobalt (Co)	6	6	3	n.d.	n.d.	n.d.	n.d.	n.d.
Manganese (Mn)	250	250	108,5	90	110	185	97	155
Vanadium (V)	10	25	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

*n. d. = not detected

The plastics content in the material correlates with the heavy metal content and is increasing with particle size of the fraction. Sieving of the organics 2 fraction from MSW (MSW O2) yields a low-polluted fine fraction, while the plastics are enriched in the coarse fraction as is shown in tableTable 6 as a result from a sieving test at 20 mm. The fine fraction < 20 mm and the fine fraction O 3 meet the requirements for co-combustion in a coal fired power plant.

Reduction of heavy metal pollution is evident. Antimony is even reduced by a factor 20. Chromium, Copper and Cadmium are also reduced significantly. With less plastic, the chlorine content is also lower.

Table 6: Sieving of fraction Organics 2 from MSW at 20 mm

Parameter	MSW O 2 >20 mm	MSW O 2 <20 mm	MSW O 3
Lead (Pb) mg/kg DM	73,9	91,4	92,7
Chromium (Cr) mg/kg DM	128,4	78,2	100,4
Copper (Cu) mg/kg DM	249,9	68,8	85,5
Nickel (Ni) mg/kg DM	78	52,2	74
Tin (Sn) mg/kg DM	80,8	88,8	61,5
Manganese (Mn) mg/kg DM	205,9	189,7	259,1
Cadmium (Cd) mg/kg DM	5,3	1,4	0,1
Mercury (Hg) mg/kg DM	n.d.	n.d.	n.d.
Antimony (Sb) mg/kg DM	293	12,9	1,1
Chlorine in % DM	1,45%	1,00%	0,38%
Heating value Hu in kJ/kg	23.587	19.626	14.616

Chlorine content is another important parameter for the properties of RDF. By separating plastics, particularly the chlorine carrier PVC and by reducing the salt content through washing we can achieve low chlorine pollution. Even co-combustion in a coal fired power plant is possible. The plastics accumulate in the fraction organics 1 (O1) with corresponding higher chlorine content (see Figure 6).

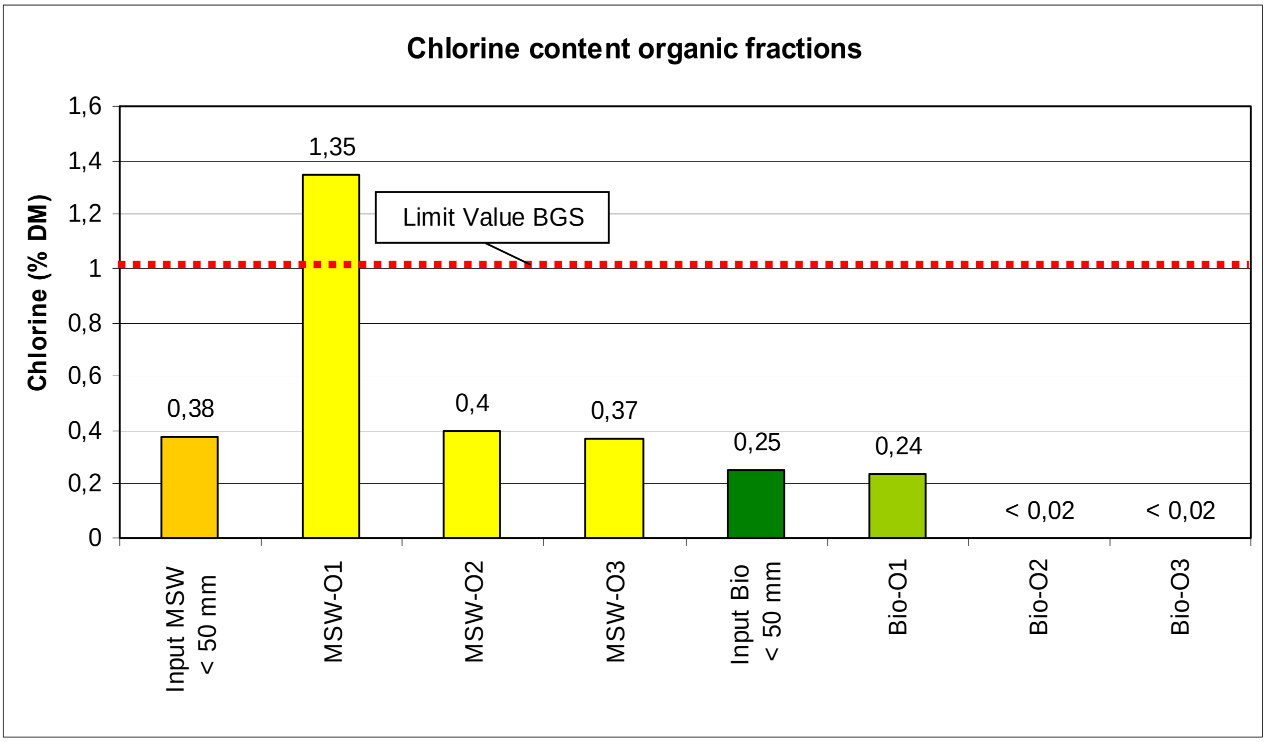

Figure 6: Chlorine content of the organic fractions from MSW and Biowaste

4.2 Biogas

The liquid phase contains the anaerobically digestible organics and is used for biogas production. Compared to anaerobic digestion processing the complete waste stream, the SCHUBIO® -Process reaches a biogas energy yield of 75 % to 85 %.

Table 7: Comparison of biogas yield of different AD processes for Biowaste and MSW

Material / Process	Nm³ Biogas / t Input	Nm³ Methane / t Input
Green waste, Biowaste		
SCHUBIO®	85 - 110	55 - 77
Kompogas - guaranteed	115	63
Kompogas – real value	125	72-80
Dranco - guaranteed	140	77
Dranco- real value	157	90
Strabag - guaranteed	115	n. s.
Strabag- real value	100 - 135	55 - 81
Bekon - real value	87	48
MSW, Household waste		
SCHUBIO®	75 - 90	49 - 63
Dry anaerobic digestion		
Valorga - real value Hannover Input < 60 mm	100	55 - 60
Dranco - real value Bassum Input < 40 mm	130	72 - 78
Wet anaerobic digestion		
Schaumburg - real value	60	39 - 45
Lübeck - design	100	n. s.
Percolation		
ISKA - real value Buchen, Heilbronn	40 - 60	26 - 45
ZAK - real value Kaiserslautern	50 - 60	33 - 45

Biogas is processed in two CHP-units with 450 kW each. The waste heat is used as process heat for the thermo-mechanical-celllysis as well as for drying the sewage sludge, sludge from the digestion tanks and the fine silt fraction from the process. The final dry matter content is 65 % to 85 %, depending on the amount of waste heat, so that the waste heat is completely used at all times.

4.3 Waste water

The waste water from AD still contains a considerable amount of nitrogen. Nitrogen from the waste water from MSW and biowaste is recovered by using a multistep chemical scrubber. The product is an ammonia-sulfate-fertilizer. The exhaust from the sludge dryer contains also nitrogen and passes the scrubber where the nitrogen is recovered.

A part of the pre-cleaned waste water is reused in the process. The excess, pre-cleaned water is treated in the municipal waste water treatment plant.

The water consumption of the SCHUBIO®-process is low, due to the high mechanical dewatering and due to the reuse of water in the process (see Figure 3).

4.4 Dried sewage sludge

The sewage sludge and the excess sludge from AD contains several important fertilizer components such as phosphorus but also Mg, K and Ca. Part of the nitrogen is driven out in the dryer, but some N is still left.

The dried sludge is incinerated in a Sewage sludge incineration plant. It is planned to recover heavy metals from the ashes, integrated into the existing fly ash washing, by reheating and evaporating the heavy metals (Schu and Seiler, 2008). The remaining ashes are then very low polluted and can be used as fertilizers. Phosphate is then recovered not only from biowaste and sewage sludge but also from MSW.

Phosphate recovery is significant because saving resources becomes increasingly important.

4.5 Inert matter

The SCHUBIO®-process produces different inert fractions, separated after grain size. These fractions are either already suitable for recycling or will be recyclable with mechanical aftertreatment. Since the market for recycling material from MSW is not established yet, the inert fractions stones, gravel and sand will be landfilled for the present. The fine silt fraction < 100 µm is more polluted because of the unfavorable weight-surface ratio. This fraction is collected separately and dried together with the sewage sludge.

5 Not recyclable fractions

All output materials described above are nearly completely recyclable. Even the polluted surplus sludge and the fine silt fraction, designed as pollutant sink of the process, can be partly recycled as material.

Only the coarse fraction from mechanical pretreatment and the fraction organics 1 are not recyclable. These fractions consist mostly of plastics. They are baled and incinerated in a waste incineration plant.

There is currently no sustainable solution for material recycling of mixed plastic in sight. Because of the high pollution level the material can only be incinerated in a waste incineration plant.

One of the main purposes of the SCHUBIO®-Process is the separation of plastics from biomass, to ensure the usability of the biomass fractions. Several process steps are important for this purpose:

1. Selective shredding and separation of a plastics-enriched coarse fraction by sieving at 100 mm.

2. The biomass from the fraction 50 – 100 mm is concentrated in the fraction < 50 mm by washing and pressing. The fraction > 50 mm contains the plastics.

3. In the fraction < 50 mm, the biomass is ground to a particle size of < 10 mm by washing and pressing at high temperature. By sieving at 10 mm, the coarse fraction with plastics is separated from the biomass fraction.

The separated biomass fractions are low polluted and can be used as substitute fuel in biomass incineration plants, coal fired power plants and cement kilns or used in agriculture as peat substitute.

The depletion of pollutants in the biomass fraction by sieving as described in chapter 4.1 causes in reverse increased pollution in the plastics enriched coarse fraction. This coarse fraction is therefore similarly difficult to recycle as the other plastics enriched fractions. The problems with the disposal of plastics with regard to their pollution level are described in a separate publication by Reinhard Schu.

6 Literature

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