Palanga Resort Solutions for Waste Management

[1]Irina, Kliopova; Jolita, Kruopienė; Jurgis, Staniškis
Kaunas University of Technology (KTU) Institute of Environmental Engineering (APINI), Lithuania
[1]irina.kliopova@ktu.lt

Abstract

The paper present results of the feasibility study *Development of biodegradable waste management system in Palanga town municipality*, which was carried out when implementing one stage of the RECO Baltic 21 Tech project, partly funded by the Baltic Sea Region Programme 2007-2013 (RECO Baltic 21 Tech project). The core of the study was to suggest the most suitable solutions for treatment of biodegradable waste (BDW), inc. from municipal waste stream and sewage sludge from waste water treatment plant in Palanga resort center (Palanga). Feasibility analysis and environmental impact assessment of 7 alternatives for centralized mechanical biological treatment system and 5 alternatives for sewage sludge aerobic treatment have been carried out. Integrated waste management model (IWMM) was suggested for Palanga after the feasible analyses of waste management alternatives. Only 20% of municipal waste will be disposed in a landfill after the implementation of the IWMM in Palanga. 90% of BDW, inc. green waste and sewage sludge, will be used for the compost production and fertilization of green territories in Palanga and for growing of energetic plants. Certain IWMM solutions can successfully be used in other resort towns as well.

Introduction

Since 2010 Lithuania is active in planning BDW separation from the other municipal waste (MW) stream. According to the Lithuanian National Strategic Waste Management Plan, amount of disposed BDW in 2020 can make no more than 35%, compared to the amount of BDW in 2000 (National Strategic Waste Management Plant 2010). National Strategic Waste Management Plan emphasizes that "green waste" (biodegradable waste from gardens, green areas and parks) must be collected and treated in composting systems, including the individual home-composting of green waste.

Palanga is the biggest resort center in Lithuania. Population of 17.2 thousand people resides in a territory of approx. 8 thousand ha, which includes 33 % of forest area. More than 100 accommodation and food establishments are operating in Palanga. Yearly more than 500 thousand tourists visit this resort. The results of initial analysis of the existing waste management system of Palanga show that (Kliopova 2012):

- Up to 16.5 thousand tonnes year^{-1} of municipal waste (MW) are generated. BDW makes more than 55% of MW.
- 90% of MW are generated during tourist season (from the middle of March to the end of November). Maximum amount of MW is up to 2.7 thousand tonnes month^{-1}.
- Approx. 80% of MW is transported to the regional landfill, which is located 35 km from Palanga. The cost for municipal waste disposal to the landfill is 37.5 euro tonne^{-1}, more than 20 euro of which is landfill tax (supposed to increase to 45 euro tonne^{-1}).
- Green waste from Palanga public territories (up to 2.500 tonnes year^{-1}) is collected and transported to the special site (total cost of green waste transportation, incl. tax, is up to 53.2 euro tonne^{-1}).
- Source separation of secondary raw materials (SRM) from MW stream started only in 2011. Thus, there is an urgent need to divert waste from the landfill, and to climb towards extracting of materials and energy from the waste.
- 1.5 thousand tonnes year^{-1} of sewage sludge is generated after biological waste water treatment and dewatering up to 20% of dry matter by mechanical press and accumulated in the special storage sites in the waste water treatment plant "Palangos vandenys" Ltd. Since 1993, a big amount of sewage sludge (about 9 thousand tonnes) has been collected in the storage sites. Recently, the waste water treatment plant focuses on the sewage sludge delivering to a bigger sewage sludge treatment plant, which is located about 35 km from Palanga. The total sewage sludge management cost is about 84 euro tonne^{-1}.

Composition and management targets of municipal waste in Palanga

The prognosis of MW generations and composition in Palanga and its management targets up to 2020 according to the Lithuanian National Strategic Waste Management Plan is presented in Table 1. Palanga has to implement MW processing techniques with minimum capacity of 9.6 thousand tonnes year^{1}, including 4.4 thousand tonnes year^{1} of BDW.

Table 1 Composition of municipal waste in Palanga, prognosis and management targets for 2020

Composition of municipal waste (MW)	**2013**	**2020**	
	Thousand tonnes year^{-1}	Thousand tonnes year^{-1}	% of the total MW
Food waste	4.8	5.5	29
Greenery waste	3.2	3.2	17
Paper and cardboard waste and packaging	1.6	1.8	10
Textile	0.1	0.1	0,3
Total BDW	**9.7**	**10.6**	**55**
Glass and glass packaging	1.2	1.4	7
Metal waste and packaging	0.4	0.5	3
Plastic waste and packaging	1.2	1.4	7
Hazardous waste, inc. electronic	0.1	0.2	1
Construction and bulky waste	2.1	2.4	12
Shorts	0.6	0.6	3
Other combustible waste	1.1	1.3	7
Other, non-combustible waste	0.7	0.8	4
Total MW	**17.1**	**19.2**	**100**
MW management target (waste treated by means different than landfilling)	**8.5**	**9.6**	50
The potential amount of BDW to landfill (National Strategic Waste Management Plant 2010)	**8.8**	**6.2**	
BDW management target (without disposal to the landfill)	**0.9**	**4.4**	

The planned efficiency of source separation in Palanga in 2020:

- Paper and cardboard waste and packaging – up to 50%;
- Glass and glass packaging – up to 50%;
- Plastic waste and packaging – up to 30%;
- Green waste from public territories – up to 80%;
- Hazardous waste, inc. electronics – up to 80%;
- Construction and bulky waste – up to 80%.

Results of laboratory analysis of Palanga sewage sludge

Based on LAND 20-2005, the sewage sludge from Palanga waste water treatment plant is attributable to category I and II according to heavy metals content and to classes A and B according to microbiological-parasitological parameters (LAND 20-2005). The total heavy metal concentration in Palanga sewage sludge is from 1.5 to 2.1 times lower than that of sewage sludge in other EU countries (see Table 2). This can be explained by the absence of manufacturing in the municipality. The relatively low metal content increases usage possibilities for the processed sewage sludge.

Table 2 Palanga sludge categorization based on heavy metal concentrations

Heavy metals	Heavy metal content , mg kg^{-1} of dry matter			
	I category (LAND 20-2005)	II category (LAND 20-2005)	Palanga	EU average ([1]BIOS, [2]KTU APINI)
Pb	<140	140-750	15-24	56.73
Cd	<1.5	1.5-20	1-4	1.68
Cr	<140	140-400	18-24	150.00
Cu	<75	75-1 000	10-125	376.98
Ni	<50	50-300	12-23	80.00
Zn	<300	300-2 500	800-1000	1 157
Hg	<1.0	1.8-8.0	0.2-0.4	2.00

[1]BIOS BIOENERGIESYSTEME GmbH;

[2]KTU APINI – Kaunas University of Technology Institute of Environmental Engineering;

Feasibility analysis of municipal waste management options

The feasibility study proposes:
- the methods for improvement of source separation of SRM and BDW, inc. SRM separation in accommodation and food establishments, green waste home-composting, using composting bins, etc.;
- the implementation of centralized mechanical (MT) or mechanical/biological treatment (MBT) system on the territory of the old landfill (7 km from Palanga) and delivery of the remaining waste to the regional landfill and /or incineration plant.

The following technical and economical alternatives for MBT have been analyzed:
1. MT with automatic separation of SRM (equipment purchase);
2. MW with semi-automatic separation of SRM (equipment purchase);
3. MT with semi-automatic separation of SRM (service purchase);
4. MBT: MT with automatic separation of SRM and BT by tunnel composting (equipment purchase);
5. MBT: MT with automatic separation of SRM and BT by container composting (equipment purchase);
6. MBT: MT service purchase and BT by tunnel composting system (equipment purchase);
7. MBT: MT service purchase and BT by container composting system (equipment purchase).

Environmental impact assessment of all the alternatives led to the selection of alternative No.7 for implementation. Environmental impact assessment showed that:
- The implementation of any of the above-mentioned MBT alternatives allows achieving MW and BDW management targets, presented in Table 1;
- MBT alternatives have better environmental benefits in comparison to MT: in case of MBT, 9.2 - 10.5 thousand tonnes year^{-1} of MW will be diverted from a landfill, inc. 4 – 5 thousand tonnes of BDW;
- Closed composting techniques for the processing of BDW fraction are proposed in the alternatives. That allows minimizing of air emissions (due to implementation of the filtering system).

Achievable results in waste management in case of implementation of the selected alternative are presented in Table 3.

Table 3 Achievable waste management results by implementation of 7th alternative (MT with semi-automatic separation and BT by container composting system)

Waste treated in accordance to targets	Volume, tonnes year^{-1}
Produced compost	3.200
SRF production	2.319
Plastic (PET, LDPE, HDPE)	600
Metal waste (magnetic)	80
Metal waste (non-magnetic)	180
Construction and bulky waste	975
Hazardous waste, inc. electronic equipment	75
Glass waste and packaging	660
MW management by MBT, tonnes year^{-1} (% of MW to MBT)	**9.208 (71%)**
BDW management by MBT, tonnes year^{-1} (% of BDW to MBT)	**4.320 (61.7%)**
Waste for disposal, tonnes year^{-1} (% of MW to MBT)	**3.791 (29)**

The best economical results will be also achieved by the implementation of the seventh alternative (see Table 4), in which MT service purchase and BT equipment purchase is suggested for the implementation. Flowchart of the process is presented in Fig.1. Main equipment of this MBT:
- semi-automatic separator of SRM (MW fraction - >50 mm);
- loader; compost tumbler;
- container composting system (1 module with automatic control: 8 containers, inc. one – for bio filter, one for compressed air preparation) with total BDW processing capacity - 5 thousand tonnes year^{-1} (MW fraction - >50 mm);
- air separator, crusher and packaging equipment for the SRF fraction separation from waste stream after MBT and improving of compost quality.

The total project investment (including designing, container composting system, building of special site for compost maturation, compost tumbler, loader, and equipment for SRF preparation) will be approx. 1.099

mil. euros. Cost of 1 tonne of MW processing is 17.23 euros. The project payback period is approximately 3.6 years.

Table 4 Results of economical evaluation of MBT alternatives

MBT alternatives	1	2	3	4	5	6	7
Evaluated aspects							
MW processing volume, thousand tonnes year^{-1}	13	13	13	13	13	13	13
Investment, thousand euros	1 518	1 198	0	2 382	2 144	1 322	1 099
[1]Operating cost without MBT, thousand euros year^{-1}	528	528	528	528	528	528	528
[1]Operating cost with MBT, thousand euros year^{-1}	405	407	332	190	228	183	224
Expenditures, thousand euros year^{-1}	493	507	332	304	343	213	254
[2]Incomes, thousand euros year^{-1}	88	100	0	114	115	30	30
Operating cost with MBT, euros tonne^{-1}	31.15	31.31	25.54	14.62	17.54	14.08	17.23
Saving, thousand euros year^{-1}	123	121	196	338	300	345	304
Payback period, years	12.3	9.9	0	7.1	7.2	3.8	3.6

Notes:

[1]Operating cost: service purchase, cost of electricity and oil consumption (for equipment), salaries of staff, cost of water consumption and wastewater, cost of non- combustible waste land filling, waste transportation cost (to MBT and to the regional landfill), inc. fuel and salaries, cost of delivering of separated combustible fraction to incineration company, cost of hazardous and non-hazardous waste (operational waste), other environmental cost (for wastewater pollution, for air pollution from mobile and stationary sources), repair costs (1% of investments per year), amortization costs (period – 10 years), cost of insurance (0.1% of investments per year).

[2] Incomes: selling of separated SRM (metal and metal packaging, PET, LDPE, HDPE) and SRF fraction; saving - up to 26.3 thousand euro per year (compost produced after the project implementation will replace a part of mould, which is usually purchased by municipality of Palanga town).

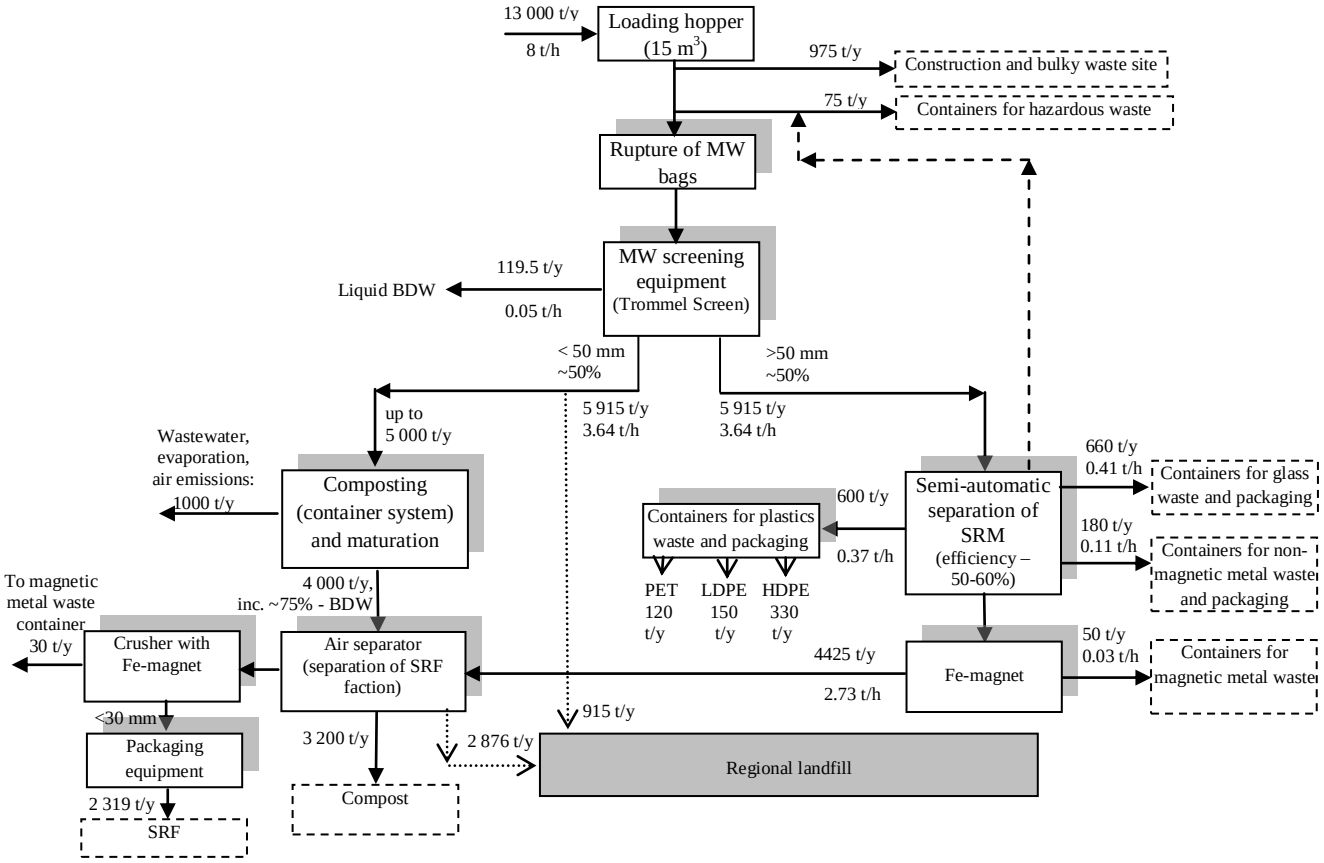

Fig. 1 Flowchart of secondary separation (centralized) and biological treatment of municipal waste in Palanga
(notes: t/y – tonnes year^{-1}; t/h – tonnes hour^{-1})

Feasibility analysis of sewage sludge management options

Feasibility study proposes the composting of sewage sludge (up to 2 500 tonnes year^{-1}) together with the green waste from public territories. Feasibility analysis and environmental impact assessment of 5 technical and economical alternatives for sewage sludge aerobic treatment has been carried out:

1. Open composting by using probiotics (service purchase; compost production);
2. Intensive composting by using container system (equipment purchase; compost production);
3. Intensive composting by using container system (equipment purchase; compost and solid recovered fuel (SRF) production);
4. Aerated windrow cover system (equipment purchase; compost production);
5. Open composting by using probiotics (equipment purchase; compost and solid recovered fuel (SRF) production).

Main results of environmental and economical evaluation of all alternatives are presented in Table 4.

Table 4 Results of environmental and economical evaluation of the analyzed sewage sludge alternatives

Comparison aspects	**1 alternative**	**2 alternative**	**3 alternative**	**4 alternative**	**5 alternative**
Volume of sewage sludge (SS), tonnes year^{-1}	**2 500**	**2 500**	**2 500**	**2 500**	**2 500**
Volume of greenery waste (GW), tonnes year^{-1}	2 500	1 250	1 250	1 250	2 500
Manufactured production, tonnes year^{-1}					
[1]compost	2 500	1 875	938	1 875	1 139
[2]SRF (in pellets form)	-	-	407	-	988
Evaluated incomes, thousand euros year^{-1}	44.90	33.68	37.20	33.68	69.88
Investment, thousand euros	**24.00**	**710.00**	**935.00**	**392.00**	**610.00**
[3]Total operating costs for SS, thousand euros year^{-1}	**98.90**	**29.70**	**69.50**	**10.00**	**55.60**
Total operating costs, euro tonne^{-1} of SS	**39.55**	**11.86**	**27.79**	**4.00**	**22.24**
Total operating costs, thousand euros year^{-1} of GW	133.00	59.00	59.00	59.00	118.00
Total operating costs for GW, euros tonne^{-1}	53.20	47.19	47.19	47.19	47.19
Cost of SS delivery to the regional waste water treatment plant (existing situation), thousand euros year^{-1}	125.12	125.12	125.12	125.12	125.12
Savings after alternative implementation, thousand euros year^{-1}	**26.22**	**95.42**	**55.62**	**115.12**	**69.52**
Pay-back period, years	**0.9**	**7.4**	**16.8**	**3.4**	**8.8**

Notes:
[1]Compost price: 17.96 EUR tonne^{-1} (under the contract with Municipality);
[2]SRF (in pellets form and low calorific value: 12 – 14 MJ kg^{-1}) an average price: 41-58 EUR tonne^{-1}.
[3]Evaluating the cost of equipment amortization (20% of total investments, an average amortization period – 10 years).

Operating costs of composting in purchased equipment for 1 tonne of processed sewage sludge is from 1.4 to 9.9 times less than in case of service purchase. Therefore, it was decided to implement own sewage sludge processing equipment.

Intensive closed aerobic sewage sludge treatment with green waste in enclosed system demands more investments compared to open composting. However, closed composting systems have certain advantages against open composting, for example:

- faster first composting period - "green" compost production: in case of container composting system - during 14-20 days, in case of open composting system – up to 2 months during warm season;
- closed composting uses less area compared to open composting;
- in case of Palanga, minimum investments in to constriction, because the already existing sewage sludge storage areas can be used for compost maturation process and for storage of produced product;
- demands less volume of inert material (in case of container composting system, up to 50% of sewage sludge volume, in case of open composting system – up to 100%);
- existing GW management costs will be reduced by 11.2%;
- composting takes place in a fully enclosed system, therefore the risk of odor and untreated air emissions will be minimized;

- air emissions are treated in bio-filters up to 98 – 99%;
- the process is fully automated, so 1-2 employers is enough for operating;
- etc.

Although the forth alternative (intensive composting by using cover system) has the best economical results (see Table 4), the operator decided to choose container composting system because of the following disadvantages of alternative No.4: composting time is 2.5 longer (up to 40 days), and cover requires changing once in 5 years.

Some waste water treatment plants analyze possibilities to produce solid recovered fuel (SRF) from dried sewage sludge. Although the net calorific value of the dried sludge is rather high (primary sludge: 13.30-17.50 MJ kg^{-1} (in dry matter), sludge after fermentation: 6.7 – 12.0 MJ kg^{-1} (in dry matter) (Wetle & Wilk 2010, Houdkova et al. 2008), but a lot of additional energy is used for sludge drying.

The evaluation of the third alternative was based on research, which was done when implementing one stage of the FP7 program project "Polygeneration of energy, fuels and fertilizers from biomass residues and sewage sludge" (ENERCOM) (No TREN/FP7/EN/218916). During research, different compositions of compost, which is produced in the company "Soil-Concept" (Luxemburg), were used. Basically, compost is made of sewage sludge after anaerobic treatment and of different types of green waste and other biomass residuals. The laboratory analysis of different compost fractions showed that fraction 10-40 mm of pre-composted materials can be used for SRF production. A net calorific value of such SRF made with 15% of the moisture content was about 12-13 MJ kg^{-1}. It corresponds to the net calorific value of the non-pressed sawdust with 30% of the moisture content. Besides, during the fist composting process, moisture content naturally decreases from 80 to 50-40% (Kliopova & Makarskienė 2012, 2013):

Main results of research in case of Palanga (Makarskienė 2013):

- Moisture content in pre-composted materials (sewage sludge and green waste) is 37%;
- Carbon content in dry matter of the pre-composted materials in case of Palanga amounts to higher than 37% in comparison to ENERCOM project;
- A net calorific value of SRF with 15% of the moisture content amounts is 14.3 MJ kg^{-1};
- The total amount of energy needed for SRF production (inc. energy for pre-composting, separation, drying, granulation, etc.) is approx. 6.5 times less than obtained during SRF combustion: 0.155 MWh MWh^{-1}. That is approx. 35% less than it was received in ENERCOM project.
- More than 50% of total energy is used for drying of pre-composted materials from 37 to 15% of the moisture content.
- For the purpose of reducing an environmental impact on the air, pre-composted materials can be mixed with sawdust (up to 10% of the total SRF raw materials volume) or SRF can be burnt together with biofuel (Kliopova & Makarskienė 2012).

After presentation of results of feasibility study to Palanga town Council, it was decided to implement project on sewage sludge processing project in 2 stages:

- Firstly, to implement composting system (open with probotics or container system – it depends on the investment possibilities). The produced compost will be used for fertilization of parks and energy plants areas in Palanga town Municipality;
- Secondly, to implement SRF production system and produce alternative fuel from the 10-40 mm fractions of pre-composting material; other fractions will be further composted. SRF will be delivered as an alternative fuel to the nearest incineration plants, for example, "Fortum Klaipėda" Ltd. (a combined heat and power station with biofuel and waste incineration plants).

Conclusions

The suggested Integrated Waste Management Model (IWMM) in Palanga town municipality is presented in Fig. 2. This model is specifically suitable for the resort area because of the following reasons:

- Palanga town municipality is a resort, visited by many tourists, including foreigners, therefore, the implementation of IWMM will allow increasing the prestige of the resort in the area of environmental performance and social responsibility;
- The IWMM proposals correspond to such options of the Waste Management Hierarchy as reuse, recycling, energy recovery. More than 80% of waste, generated in this municipality, will be treated differently than landfilling: a waste will be converted to products or to the raw materials for new products production;

- A distance of over 35 km from Palanga to the regional landfill and to sewage sludge treatment place increases the costs of waste transport and general waste management;
- From 2016 landfill tax will be applied for unproceeded municipal waste, and it will increase from the current 20 euros per tonne of MW to 45 euros per tonne;
- Amount of municipal waste generated per capita in Palanga is 2-3 times higher than the EU average, as the per capita up to 30 tourists, therefore, the application of the landfill tax will considerably increase municipal waste management cost for local residents;
- BDW makes more than 55% of municipal waste; packaging waste – up to up 26%;
- Several disturbances of small tourist towns hinder the increase the efficiency of the source sorting of SRM and BDW prvided in the model: not enough vacant land for sorting containers; high cost of land; there is no technical possibilities for more often collection of municipal waste, especially during the tourist season. Feasibility study provides some management options for the compensation of these disturbances.

Only 20-22% of generated MW will be disposed in a landfill after the implementation of the IWMM in Palanga. Most of waste will become new products or raw materials for production of new products. 90% of BDW, including green waste and sewage sludge, will be used for the compost production and fertilization of green territories in Palanga and for growing of energetic plants. Moreover in a nearest future, alternative energy fuel - SRF - will be produced from the part of pre-composted materials.

The implementation of IWMM will allow receiving the main social benefits:

- the price of MW for local residents will not increase after increasing of landfill tax;
- the price of sewage sludge processing will be decreased up to 2.2 times.

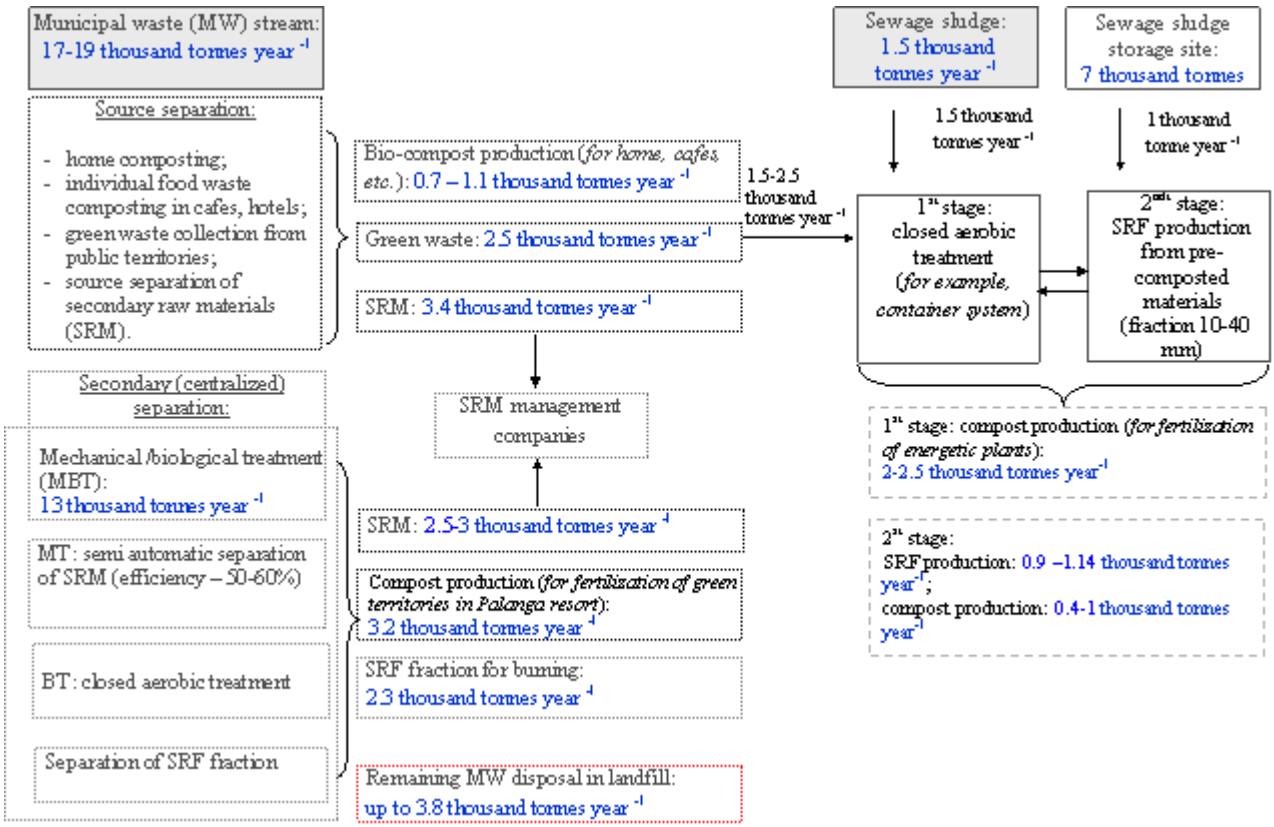

Fig.2 Integrated Waste Management Model (IWMM) for Palanga town municipality

References

- Houdkova, L., Boran, J., Ucekaj, V, Elsaber, T & Stehlik P. (2008) Thermal processing of sewage sludge II. Applied Thermal Engineering, 28, 2083–2088
- ENERCOM (2008-2013). Summary and objectives of Collaborative project Polygeneration of energy, fuels and fertilizers from biomass residues and sewage sludge: http://www.enercom.stoffstrom.org
- Kliopova, I. (2012). Galimybių studija. Biologiškai skaidžių atliekų tvarkymo sistemos vystymas Palangos miesto savivaldybėje / Feasibility study. Development of biodegradable waste management system at Palanga city municipality. RECO Baltic-21 Tech project, pp. 149. Kaunas, Lithuania
- Kliopova, I., Makarskienė, K. (2012) Generation of Solid Recovered Fuel from Sewage Sludge Compost. Environmental Research, Engineering & Management, 4(62), 39-42
- Kliopova, I., Makarskienė, K. (2013) Generation of solid recovered fuel from the separate fraction of pre-composted materials (sewage sludge and biomass residues). Environmental Research, Engineering & Management, 2 (64), 5-18
- Makarskienė, K. (2013). Magistro darbas. Kietojo atgautojo kuro gamyba iš nuotekų dumblo ir biomasės atliekų / Master thesis. Generation of solid recovered fuel, pp. 117. Kaunas, Lithuania
- LAND 20-2005. Requirement of sewage sludge usage for fertilization and restoration. Ministry of Environmental of the Republic of Lithuanian (2005) (last addition – 2012 No. D1-76)
- National Strategic Waste Management Plan (NSWMP) Approved by Resolution of the Government of the Republic of Lithuania (No.519, 2002; last additions – 2010).
- Obernberger, I., Brunner, T. & Polzer, A. (2009). Generation of raw materials: report on input fuel analysis. Publishable summary. ENERCOM. BIOS, pp 43. Graz, Austria
- RECO Baltic-21 Tech project: http://www.recobaltic21.net/en.html
- Wetle, S., Wilk. R. (2010) A review of methods for the thermal utilization of sewage sludge: the Polish perspective. Renewable Energy, 35, 1914-1919.