ACHIEVING LEGISLATION TARGETS VIA AN INTEGRATED WASTE MANAGEMENT FACILITY: CYPRUS CASE STUDY

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Abstract

The landfilling of biodegradable waste may bring about adverse effects on the environment, specifically on surface water, groundwater, soil, air and human health. The introduction of the Landfill Directive 99/31/EC resulted in the development of new waste management strategies within all European countries and therefore also in Cyprus, waste management is facing new challenges. The objective of the Directive is to prevent or reduce the negative effects on the environment from the landfilling of waste as far as possible by introducing stringent technical requirements for waste and landfills. According to the Cypriot National Waste Management Plan, each region should individually achieve the legislation requirements for the recycling of packing material and diversion of biodegradable waste from landfill. The regions of Larnaca and Ammochostos previously had no recycling systems in place and were disposing all their waste in uncontrolled dump sites. In order to comply with the legislative requirements they prepared a Regional Plan according to which priority was given to the sorting at source of recyclable materials and green wastes. The new waste management facility in Larnaca – Ammochostos regions of Cyprus is the first facility that focuses on the recovery of recyclable waste and reduction of the amount of biodegradable organic wastes going to landfill by various treatment processes of the waste.

The facility is designed to handle mixed municipal solid waste (MSW) and is located at the location of Nafkias, which belongs to the Kochi Community of Larnaca's Region, in the southeast of Cyprus. The permanent population served is 200.000 citizens, the area also being seasonally highly touristic resulting in an annual waste production of approximately 176.000 ton/year. The innovative aspect of the facility is that it can handle both mixed and source separated material and can produce compost and SRF simultaneously, so it has a high degree of flexibility and can easily adopt to a change in the waste composition, and any future changes of market requirements for end products. Specifically, this integrated waste management facility includes the following installations:

a) A Mechanical – Biological Treatment Plant (MBT) for the treatment of solid waste, with a capacity of 160.000t/yr of mixed municipal solid waste from households, up to a possible maximum capacity of 220.000t/yr
b) A Material Recycling Facility (MRF) 20.000t/yr, for the recovery of recyclables sorted at source
c) A Composting Plant for the composting of the organic material sorted at source, with a design capacity of 16.000t/yr
d) A Sanitary Landfill site with an annual capacity of 88.000t/y and a minimum time-life of 20 years

The mechanical treatment plant combines the operations of bag-opening, screening, metals (FE & AL) separation as well as optical sorting with Near Infrared (NIR) sorters, aiming to retrieve the greatest amount of high quality recyclable materials and to separate organic materials from the remaining fraction. Organic material is dispatched to the biological treatment plant and the recyclable materials are dispatched to the respective recycling units. Materials rejected by the process are dispatched to landfill. The organic fraction from the MSW is segregated and finally treated in the composting plant. All sorting and intensive composting are fully automated processes which are conducted in fully enclosed buildings without appreciable emissions of odour or pollutants to the environment. The composting plant operates as negative aeration system (suction aeration) meaning that air is sucked off through the aeration pipes in the ground. The waste air from the composting process is treated by high temperature combustion using the patented 'LARA' system. The maturation unit is designed as aerated closed trapezoid windrows. The reason for the chosen system is the higher achieved quality of the final compost and the very low energy

consumption. The main benefit of composting is that the mature product (compost) can be used on soil as a fertilizer or in preparation of growth media for cultivation of soil. The residuals from the treatment processes are disposed in the sanitary landfill, located within the IWM site boundaries, according to the specifications of the Landfill Directive.

The preliminary design, the application for funding from the EU Cohesion Fund and the construction supervision was performed by ENVIROPLAN S.A.. The construction of the facility started in 2007 and was carried out by HELECTOR S.A. and the facility is presently starting its full operation after a successful trail period.

1. Introduction

There are a number of types of facilities that can be used for waste management. These vary in their environmental impacts and some are more suited to particular wastes and waste streams than others. All waste facilities and options will involve some degree of environmental risk. The aim of recycling and composting is to recover as much value as possible from waste via separation and reprocessing before final disposal. However, even if recycling and composting are maximised there will still be residual waste for further treatment and disposal. Thermal Treatment and Landfill are two methods of disposal of this residual waste. The recovery of materials from municipal solid waste can be achieved by applying alternative methods and technologies, according to the type of solid waste that is to be subjected to sorting and the types of materials that are foreseen / required to be recovered and further utilised. Mechanical Biological Treatment (MBT) is an *intermediate method* for further reducing the amount and environmental impacts of residual waste and increasing the recycled fraction. It is a process which recovers materials and energy from 'residual' waste – the waste left over after recycling by separation at source. The aim of the process is to further reduce environmental impacts before disposal of residual waste and to gain additional value from the recovery of metals, glass, plastics, papers with the possibility of energy generation. Though MBT technology reduce and stabilise wastes it still leaves a proportion of residual waste which must go for final disposal either by landfilling or by some means of thermal treatment. It is not therefore, a 'stand-alone' treatment for residual waste but is an *intermediate process* usually requiring integration within a waste disposal facility. A mechanical biological treatment system is a form of waste processing facility that combines a sorting facility with a form of biological treatment such as composting or anaerobic digestion. MBT plants are designed to process mixed household waste as well as commercial and industrial wastes.

According to the Cypriot National Waste Management Plan, each region should individually achieve the legislation requirements for recycling of packing material and diversion of biodegradable waste. The new waste management facility in Larnaca – Ammochostos regions of Cyprus is the first facility that focuses on the recovery of recyclable waste and reduction of the amount of biodegradable organic wastes going to landfill, through the utilisation of various treatment processes of the waste. The integrated facility at Nafkias consists of the following plant/installations:

- A Mechanical – Biological Treatment Plant (MBT)
- A Material Recycling Facility (MRF)
- A Composting Plant for the composting of the organic material sorted in the source
- A Sanitary Landfill Facility

2. Description of the integrated waste management facility

The Nafkias integrated waste management facility at is based on principles described in EU directives regarding the management of waste, which include:

- the protection of the environment and improvement of the quality of life,
- the protection of human health against harmful effects caused by the management of waste,
- the prevention, recycling and processing of waste,
- the extraction of raw materials and possible energy from waste processing,
- the disposal of waste without risk to water, air, soil, plants and animals, without causing a nuisance through noise or odours and without adversely affecting the countryside or places of special interest, and

- the principle “the polluter pays” according to which the cost for the disposal of waste should be borne by the holder or producer of the waste.

The main purpose of this facility is to help the municipalities and communities of Larnaca and Ammochostos regions in managing the quantities of municipal solid waste produced in the regions. The project is also required by the “Strategic Plan for Solid Waste Management in Cyprus (2003)”.
The facility is designed to handle mixed municipal solid waste (MSW) and is situated at the location of Nafkias, which belongs to the Kochi community of Larnaca’s region, in the southeast of Cyprus. The permanent population served is 200.000 citizens the area also being seasonally highly touristic resulting in an annual waste production of approximately 176.000 ton/year.

2.1. Mechanical – Biological Treatment Plant

This plant includes the below individual units:

- Control and weighing of entering and exiting vehicles unit.
- Waste reception and metered supply unit for the downstream separation unit.
- Mechanical Separation and Hand Sorting facility.
- Compaction and Balling of Papers, Plastic, Ferrous Metals and Aluminium facility.
- Storage Unit of recovered materials.
- Composting Unit for recovered organic materials
- Storage Unit for the Maturation and Standardization of the produced compost.
- Compost Refinement Unit

Figure 1: Integrated Waste Management Facility at Nafkias, Kochi Community, Region of Larnaca CYPRUS

The mechanical treatment plant combines the operations of bag-opening, screening, metals (FE & AL) recovery as well as optical sorting with Near Infrared (NIR) sorters, aiming to retrieve the greatest amount of high quality recyclable materials and to separate organic materials from the rests. Organic material is dispatched to biological treatment and recyclable materials are dispatched to the respective recycling units. Materials rejected by the process are dispatched to landfill. The organic fraction from the MSW is segregated and finally treated in the composting plant. All sorting and intensive composting are fully automated processes which are carried out within enclosed buildings without appreciable emissions of odour or pollutants to the environment.

The composting plant operates as a negative aeration system (suction aeration) meaning that air is sucked off through the compost to aeration pipes in the ground. The waste air is finally treated by high temperature combustion using the patented ‘LARA’ system. The maturation unit is designed as aerated closed trapezoid windrows. The reason for the chosen system is the higher achieved quality of the final compost in less time with a very low level of energy consumption. The main benefit of composting is that the mature product (compost) can be used on soil as a fertilizer or in preparation of growth media for

cultivation of soil. The residuals from the processes are disposed of in the sanitary landfill, located within the same land area, according to the specifications of the Landfill Directive.

2.2. Mechanical Separation / Material Recovery and Hand Sorting Facility (MRF)

The Materials Recovery Facility is to process the dispatched recyclable materials from the MBT plant as well as the recycled material from the program of sorting at the source.
The waste fraction passes though the bag-openers after which it is size sorted by the first and second stage drum screens then being fed to a ballistic separator, where it is further separated into 'heavy or rolling objects' and 'light or flat objects'.

The heavies are received by a collecting conveyor belt which is located at the base of the ballistic separator, and are initially led off to the first NIR separator for the reclamation of PET and mixed plastic bottles and then further led to a second NIR separator for the reclamation of mixed papers or plastics of type PE/PP, by preference. The streams of products which are reclaimed by the NIR separators are collected by conveyors which lead to the 'quality control' hand picking cabin located within the main Mechanical Separation building and on to the product balers, while the stream of 'unwanted' materials are led off to collection bins and from there to landfill.

The light materials from the ballistic separator are received by a conveyor which leads them to an NIR separator which is regulated to recover plastic 'films' and PVC. The remainder is fed though a second NIR separator for the recovery of paper and cardboard. The remainder of this stream constituting Refuse Derived Fuel (RDF) is led though the hand picking cabin for the recovery of chance remaining valuable recyclables (Al & FE) and on to the product balers.

The stream of light materials from the ballistic separator remaining after the first NIR separator is subjected to yet another NIR separator for the reclamation for plastic films and the removal of PVCs and other mixtures. The plastic films are then fed through the handsorting cabin and on to the product balers, and the remaining 'rests' are led to a collection bin for disposal in the landfill. The stream of materials from the light fraction from the ballistic separator after the second NIR separator and after the paper and cardboard have been recovered, is subjected to another NIR separation whereby the cardboard is separated out. The cardboard is then led though the handsorting cabin, as is the case for the paper fraction also, whereby the papers and 'printed' papers are separated out. The unwanted 'rests' from the handsorting cabin are led to collection bins for landfill for disposal.

The recyclable materials from any 'separation at source' programs are also delivered to the mechanical separation building, which are in turn separated and then baled. There is a specially allocated area between the main waste reception building and the mechanical separation building where the 'separation at source' materials are unloaded. These materials may arrive either in mixed form (from the 'blue bin' system) or already separated by product. The mixed recyclables are fed into the mechanical separation system though a specifically designated input bay, and from there the system is able to treat these materials as a separate 'clean' waste stream (no organics present) producing extremely high quality products.

Figure 2: Material Recovery Facility at Nafkias, Kochi Community, Region of Larnaca CYPRUS

2.3. Composting Plant

The main benefit of composting is that the mature product (compost) can be used on soil as a fertilizer or in preparation of growth media for cultivation of soil. The reason for the chosen system is the higher achieved quality of the final compost in less time with a very low level of energy consumption. The intensive composting activities are fully automated and are carried out within fully enclosed controlled

atmosphere buildings without appreciable emissions of odours or pollutants to the environment, the waste air being treated by a high temperature combustion system using the patented 'LARA' system manufactured by Herhof GmbH. The Composting Plant treats the green wastes which amount to approximately 23.920 tons/year segregated organic fraction from the MSW (from the mechanical separation plant) as well as the 16.000 tons/year organic materials that will be collected by the program of Separation at source, these having been calculated in the overall capacity of Mechanical Separation – Hand sorting unit. The composting plant operates as negative aeration system (suction aeration) meaning that air is sucked off through the compost to aeration pipes in the ground, this greatly reduces the creation and dispersion of dusts and odours.

The organic material from the Separation at Source programs are delivered to a covered pre-designated area outside the composting plant, from where they are fed though a shredder, and then fed via a conveyer system to the automatically selected composting boxes. The organic fraction of the MSW from the mechanical separation plant arrives at the Composting Plant via a covered conveyer connecting the two buildings, from where it is also fed via a conveyer system to the automatically selected composting boxes. The two streams of organics are kept separate, with the materials form the separation at source program producing category 'A' compost, and the organic fraction from the MSW producing category 'B' compost. After remaining in the closed composting boxes for a period of up to 10 days, the exiting materials are fully hygenised, which are then removed to an external covered maturing area to form windrows. The windrows are periodically 'turned' and wetted by a specialized 'compost turning' vehicle for a period of five weeks so as to complete the stabilization process. It is here that the maturing process of the compost is completed.

After the maturation, the composts of the two separate categories are fed to the Compost Refinement Unit where they are 'cleaned' from impurities utilising screen drums. The refinement unit consists of two separate production lines, one for each of the categories. Approximately fifteen percent (15%) of the produced compost (with preference given to the category A product) is bagged up in sacks which are in turn stacked on palettes and wrapped in plastic sealing film ready for shipment. The remaining eighty-five percent (85%) of the produced compost is stored in triangular windrows in a covered outside area to be supplied in loose form for use as landfill cover or other uses.

2.4. Sanitary Landfill Site

The total basin area of the sanitary landfill is 113 hectares and has been constructed in two phases giving a total capacity of 2,8 million m^3. The landfill covers has been designed for 20-years of operation calculated using an operational capacity of 88.000 tn/year of residuals from the neighbouring MBT plant.
The basic infrastructure works of the landfill site are the following:

- Sealing works: The creation of a strong tight sub-base and to increase of protection of the area a system of composite sealing has been used
- Leachate Pipe network: The collection of leachate in each cell is to be carried out by a network of submersible pumps and HDPE piping:
- Leachate Treatment Installation: The leachate treatment will be carried out in two phases. The first phase includes the first stage treatment by aeration and precipitation of suspended matters, and the second phase include further treatment by the method of reverse osmosis.
- Collection network and biogas combustion facility: In each phase of the Sanitary Landfill development, in parallel with the process of sanitary landfilling, a network of piping for the collection of biogas will be installed. The collected biogas, also being fared off initially, could be exploited for energy reclamation in the future.

3. Results and discussion

The permanent population served by the Integrated Waste Facility at Nafkias is 200.000 citizens. The regions of Larnaca and Ammochostos are seasonally highly touristic resulting in an annual waste production of approximately 176.000 tn/yr (equal to 160.000 tn/yr urban waste and 16.000 tons/year green waste).
The average capacity of the Mechanical Sorting Plant for mixed waste amounts to 160.000 tn/yr, or since it will operate six days a week for 14 hours a day (two shifts) to: 516 tn/day or 40 tn/hr (considering no

input of recovered materials form the Separation at Source programs). As a result it includes two lines of treatment each with an average capacity of 20tons/ hour.

Respectively, the Composting Plant treats the organic materials that are recovered by the Mechanical Sorting Plant. Considering that a least 65% of the content of the organic materials from the MSW will be recovered, this results in a capacity of: 0,65 X 0,23 X 160.000 tn/yr = 23.920 tn/yr plus the 95% of the 16.000 tn/yr green waste from the separation at source program. Thus the capacity of this unit is appreciated at 23.920 + (95% x 16.000) = 39.120 tn/yr or ≈125 tn/day (for a six day per week operation).

Table 1: Recovered Materials of the Material Recovery Plant (as per design value of 176.000 t/yr and no separation at source)

COMPOSITION	**Content (% p.w.)**	**Quantity (tn/year)**	**Rate of Recovery**	**Recovered quantity (tn/year)**	**Residuals (tn/year)**
Urban Waste					
Putrecibles	25.28	40.480	65%	26.312	14.168
Papers	30.77	49.280	45%	22.176	27.104
Plastic	17.58	28.160	45%	12.672	15.488
Glass	2.20	3.520	45%	1.584	1.936
Ferrous	3.30	5.280	70%	3.696	1.584
Aluminium	1.1	1.760	70%	1.232	528
Textile, leather, timber, rubber	9.90	15.840			15.840
Others	9.9	15.840			15.840
	100,00	*160.160*		*67.672*	*92.488*
Green waste		15.840	95%	15.048	792
TOTAL	**100%**	**176.000**		**82.720**	**93.280**

3.1 Final Products

According to the above mentioned dimensioning of the plants as well as the technical characteristics of the adopted technologies in the facility, the next table presents the average (operating at 160,000 t/yr MSW) and the maximum (operating at 200,000 t/yr MSW) quantities of the products recovered.

Table 2: Products from the Integrated Management Facility

Products	**Average recovery of products (tn/day)** - 160,000 t/yr MSW	**Maximum recovery of products (tn/day)** - 200,000 t/yr MSW
Compost from mixed waste	59,3 tn/day	74,05 tn/day
Compost from pre-shorted green waste	17,88 tn/day	17,88 tn/day
Printed Paper	20,31 tn/day	25,36 tn/day
Mixed Paper	72,43 tn/day	90,45 tn/day
Cardboard	21,94 tn/day	27,40 tn/day
RDF	28,26 tn/day	35,29 tn/day
Plastics	39,06 tn/day	48,78 tn/day
PET	2,78 tn/day	3,47 tn/day
PE/ PP	12,09 tn/day	15,09 tn/day
Fe	17,73 tn/day	22,14 tn/day
Al	4,53 tn/day	5,66 tn/day
Glass	5,17 tn/day	6,45 tn/day
Residuals	167,2 tn/day	207,33 tn/day
Total	**468,6 tn/day or 145.266 tn/yr**	**579,3 tn/day or 180.750 tn/yr**

3.2. Wastewater treatment

Within the integrated waste management facility waste waters are produced by the composting facility, the landfill (leachate and condensates from the biogas), the vehicle servicing and washing facility and the operations center building (sewerage waters). Apart from the composting facilities waste waters which are processed within the unit, the remainder are led to the central Wastewater Treatment Plant. The following table presents the quantities and origins of the produced waste waters.

Table 3: Type and Origin of produced wastewater before treatment and/or mixing

Type and Origin of produced wastewater	**Produced Quantity**	
	m^3/ day	**m^3/έτος**
Leachate from landfill site	130	40.300
Composting plant's wastewater	27	8.370
Cleaning waters, sewerage waters, Biogas network condensate etc.	35	10.850
Total quantity of discharge wastewater	192,0	59.520,0

Composting facilities' waste water treatment installation. – Within the air circulation network of the composting plant condensates are formed from the exiting air of the closed composting boxes. These condensates are led to an autonomous waste water treatment installation where, after treatment, the clean waters are reused as supplement cooling waters in the cooling tower. The treatment system is an MBR (Membrane Bioreactor) type reactor requiring a small surface area while having a high performance. It involves suspended growth activated sludge systems utilising ultrafiltration membranes, and therefore not requiring a separate sedimentation tank. The system in use consists of a compact design which produces treated water suitable for re-use within the composting facility. The composting facility's waste water treatment installation can be by-passed (in the instance of malfunction or maintenance) so that the waste waters are lead to the sewerage network, and from there to the central landfill waste water treatment plant. The waste waters produced by the composting process are fully re-circulated within the system, from which there is no surplus requiring disposal.

Landfill site waste water treatment plant – The treatment of the waste waters collected from the Landfill (leachate and condensates from the biogas collection network), the Vehicle Servicing and Washing facility and the Operations Center Building (sewerage waters) occur at the central landfill Waste Water Treatment plant. It has been designed for a hydraulic load of 130 m^3/d of leachate from the landfill, and an extra 35 m^3/d from the other various origins of production as mentioned above. The employed reverse osmosis unit with a capacity of 200 m³/d and consisting of two stages, can withhold all the macromolecules, the charged ions 2^+ or larger and the microbial load. The concentrate from the reverse osmosis (40% of the feed waters) is led to the 'remains' storage tank, while the clean liquids after passing though a degasifier are led to the clean water storage tank. The unit is sized to suffice for the total projected production of leachate from the landfill, and achieves an exit flow with very low concentrations of pollutants ($BOD_5 \leq$ 20 mg/l, N≤ 15 mg/l, COD ≤150 mg/l) offering a high level of flexibility and adaptability to any changes in the flow rates and input loads. The clean fluids are used for irrigation purposes of the waste management facility, while the 'remains' are re-circulated within the body of the landfill. The total of all the polluting substances are filtered out by the reverse osmosis unit, which is designed to be suitable for the treatment of fresh leachate.

Table 4: Type and quantity of treatment wastewater to discharge

Type and Origin of treatment wastewater	**Quantity (m^3/ day)**	**Produced**
'Remainders' from the reverse osmosis process	66	Re-circulation within the landfill
Clean waters from the reverse osmosis process	99	Surface irrigation of the waste management facility
Total quantity of discharged (treatment and/or not treatment) wastewater	165	

3.3. Produced Solid wastes and sludge's

As concerns the solid wastes produced by the waste management facility, these are of minimal quantities and which are due mainly to

a) Sludge from the settlement tank, specifically de-watered sludge resulting from the sack filtering unit, and
b) The dusts collected from the various air filtration installations within the facility (mainly from the reception building and mechanical separation building). These are collected by the 'sack-filters' in sealed sacks.

The above solid wastes are not utilized any further but are led to the landfill for disposal.

4. Conclusions

MBT facilities can have a significant role as a 'secondary recycling stage'. Even where local authorities have a well-developed kerbside collection in place, MBT enables an increase in recycling rates and therefore a decrease in landfilled quantities. It is claimed that some MBT systems can recover 15-20% from the residual waste after source recycling. In addition, the quality of recycled metals from an MBT is higher than from incineration and so have a higher value. The placement of MBT remainder material in landfill has a number of advantages over landfilling untreated waste the main one being a much reduced biodegradation factor. Leachate and landfill gas are reduced to about 10% of that produced by untreated waste. It reduces both the cost of managing the landfill site and potentially the long term liability of the site. Furthermore there is less waste to deposit in the landfill site, the weight and volume having been reduced by up to 45%. Additionally, some parts of the waste can be further treated to produce Refuse Derived Fuel (RDF) which has a much higher calorific value than that of untreated waste. This allows energy to be recovered from the material produced, thereby greatly increasing the value recovered from the waste.

During the present phase of operation of the waste management facility, the separation at source programs have not been developed within the region to a level providing any significant results. Hence the facility is currently operating treating almost exclusively MSW. As the separation at source programs become more developed, the percentage of materials from this stream will increase in parallel with a decrease in the quantities of MSW since the pre-selected waste fraction forms a percentage of the MSW. The facility has been designed with this in mind and the operation of the facility is able to adapt instantly and automatically to the levels and types of the incoming materials from any development in the Separation at Source programs by the regulation of the throughput of the two separate production lines.

The innovative quality of plant is that it can handle both mixed and source separated material and can produce compost and SRF simultaneously, so it has a high degree of flexibility and can easily be adopted to any changes in waste composition, and the requirements of the markets for end products in the future.

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POSTIZANJE ZAKONSKIH CILJEVA USPOSTAVOM CENTRA ZA GOSPODARENJE OTPADOM: CIPAR, ANALIZA SLUČAJA

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Ključne riječi (5 to 10): Mehaničko – biološka obrada, kompostana, Direktiva o odlagalištima 99/31/EC, optičko sortiranje

Sažetak

Odlaganje biorazgradivog otpada može uzrokovati nepovoljne utjecaje na okoliš, prvenstveno na površinske vode, podzemne vode, tlo, zrak i ljudsko zdravlje. Primjena Direktive o odlagalištima 99/31/EC rezultiralo je razvojem novih strategija gospodarenja otpadom u svim europskim zemljama pa tako i na Cipru. Gospodarenje otpadom se suočava sa novim izazovima. Cilj direktive je spriječiti ili smanjiti negativne učinke odlaganja otpada na okoliš uvođenjem strogih tehničkih zahtjeva za odlaganje otpada. Prema Nacionalnom planu za gospodarenje otpadom Cipra, svaka regija mora samostalno ispuniti zahtjeve zakonodavstva za recikliranje ambalažnog otpada i odvajanje biorazgradivog otpada. Regije Larnaca i Ammochostos nisu imale razvijen sustav recikliranja i odlagale su sav svoj otpad na neuređena odlagališta. U skladu sa zahtjevima zakonodavstva, sastavili su Regionalni plan prema kojem je dan prioritet odvajanju iskoristivog otpada na mjestu nastanka. Novo postrojenje za gospodarenje otpadom u regijama Larnaca-Ammochostos je prvi sustav koji se fokusira na oporabi recikliranog otpada i smanjenju količine biorazgradivog organskog otpada kroz razne postupke obrade.

Postrojenje je konstruirano za obradu miješanog komunalnog otpada i locirano je u Nafkiasu, koji pripada Kochi zajednici u regiji Larnaca, na jugoistočnom dijelu Cipra. Na ovome području obitava 200.000 stanovnika, a broj se povećava u vrijeme turističke sezone, tako da se godišnje proizvede oko 176.000 tona otpada. Inovativan aspekt postrojenja je taj da se može baviti i miješanim komunalnim i odvojeno skupljenim otpadom te može istovremeno stvarati kompost i gorivo iz o0ptada, što znači da ima visok stupanj fleksibilnosti i može se adaptirati na promjene sastava otpada i za bilo koje promjene na tržištu u budućnosti. Ovo integrirano postrojenje za gospodarenjem sastoji se od:

- Postrojenja za mehaničko – biološku obradu otpada (MBO) sa kapacitetom od 160.000 tone godišnje za obradu miješanog komunalnog otpada iz domaćinstava, sa maksimalnim kapacitetom od 220.000 tone godišnje;
- Postrojenje za recikliranje otpada (MRF), 20.000 tona godišnje, za odvojeno skupljeni otpad na mjestu nastanka;
- Uređaj za kompostiranje organskog materijala odvojenog na mjestu nastanka , sa kapacitetom od 16.000 tona godišnje
- Sanitarno odlagalište sa godišnjim kapacitetom od 88.000 tone i minimalnim vijekom trajanja 20 godina

Postrojenje za mehaničku obradu otpada kombinira procese otvaranja vrećica za otpad, prosijavanje, odvajanje metala (FE & AL) kao i optičko sortiranje sa bliskim infracrvenim (NIR) sortirkama, separatorima, s ciljem da se od postojeće frakcije dohvati što veća količina recikliranog materijala visoke kakvoće i odvoji organski materijal. Organski materijal otprema se na biološku obradu, a reciklirani materijali do jedinice za recikliranje. Materijali odbačeni tokom procesa odlažu se na odlagalište. Organska frakcija iz miješanog komunalnog otpada se odvaja i konačno tretira u kompostani. Sortiranje i kompostiranje su automatizirani procesi koji se provode u zatvorenim prostorijama bez primjetne emisije neugodnog mirisa ili polutanata u okoliš. Kompostana radi na principu negativnog sistema aeracije (usisavanje zraka), što znači da je zrak usisan kroz cijevi u zemlji. Onečišćen zrak nastao kompostiranjem, sagorijeva pod visokom temperaturom izgaranja pomoću „LARA“ sistema. Jedinica za sazrijevanje projektirana je kao niz trapezoidnih redova u kojima je omogućena aeracija. Razlog za takav sustav je postizanje visokog stupnja kakvoće završnog komposta i male potrošnje energije. Najveća korist kompostiranja je dobivanje komposta koji se upotrebljava kao umjetno gnojivo ili kao dodatak za

kultiviranje tla. Ostaci koji nastaju nakon obrade odlažu se na sanitarno odlagalište, koje se nalazi unutar granica IWM postrojenja, prema specifikacijama Direktive.

Preliminarni plan izvedbe, prijava za dobivanje sredstava iz kohezijskih fondova EU i nadziranje izgradnje obavila je tvrtka ENVIROPLAN S.A.. Izgradnja postrojenja počela je 2007. godine od strane tvrtke HELECTOR S.A. te je postrojenje počelo sa radom nakon uspješnog probnog perioda.

1. Uvod

Postoji niz različitih postrojenja za gospodarenje otpadom. Ona se razlikuju po svom utjecaju na okoliš a neka više odgovaraju obradi pojedinih vrsta otpada od drugih. Sva postrojenja, odnosno sve opcije gospodarenja otpadom predstavljat će određeni rizik za okoliš. Cilj recikliranja i kompostiranja je oporaba što veće vrijednosti iz otpada putem separacije i obrade prije finalnog odlaganja. No, i kod maksimalnog recikliranja i kompostiranja postojati će određena količina ostatnog otpada za daljnju obradu i odlaganje. Dvije metode zbrinjavanja ovog rezidualnog otpada su termička obrada i odlaganje. Oporaba materijala iz komunalnog otpada može se postići korištenjem alternativnih metoda i tehnologija, ovisno o vrsti otpada koja će se podvrgnuti odvajanju i vrsti materijala koje se namjerava izolirati kako bi se mogli oporabiti i ponovo koristiti. Mehanička biološka obrada je međutehnologija koja omogućuje smanjenje količina i negativnog utjecaja na okoliš rezidualnog otpada, kojom se povećava udio recikliranog materijala. To je proces kojim se oporabljuju materijali i energija iz rezidualnog otpada – otpada koji preostaje nakon recikliranja i odvajanja na mjestu nastanka. Cilj procesa je smanjenje negativnog utjecaja na okoliš prije odlaganja rezidualnog otpada te dobivanje dodatne vrijednosti oporabom metala, stakla, plastike, papira s eventualnom mogućnosti stvaranja energije. Iako MBO tehnologija reducira i stabilizira otpad i dalje ostaje dio rezidualnog otpada koji mora proći finalnu obradu ili odlaganjem na odlagalištu ili nekom termičkom metodom. Ovo nije „samostalan“ tretman za rezidualni otpad, već prijelazni proces koji obično zahtjeva integraciju unutar postrojenja za odlaganje otpadom. Postrojenje za mehaničko-biološku obradu otpada vrsta je postrojenja koja kombinira objekt za sortiranje otpada s jednim od objekata za biološki tretman, kao što su kompostiranje ili anaerobna digestija. Ova postrojenja projektirana su za obradu miješanog komunalnog otpada i proizvodnog otpada. Prema Nacionalnom planu gospodarenja otpadom Cipra, svaka regija mora samostalno izvršiti zahtjeve zakonodavstva za recikliranje ambalažnog otpada i odvajanje biorazgradivog otpada. Novo postrojenje za gospodarenje otpadom u regiji Larnaca – Ammochostos na Cipru prvo je postrojenje koje se fokusira na oporabu otpada koji se može reciklirati i smanjenje količina biorazgradivog otpada koje se odlažu na odlagalište, korištenjem različitih metoda obrade otpada. Cjelovito postrojenje u Nafkiasu sastoji se od slijedećih objekata/uređaja:

- Postrojenje za mehaničko – biološku obradu otpada (MBO)
- Postrojenje za recikliranje otpada (MRF)
- Pogon za kompostiranje organskog materijala odvojenog na mjestu nastanka
- Sanitarno odlagalište

2. Opis integriranog postrojenja za gospodarenje otpadom

Cjelovito postrojenje za gospodarenje otpadom u Nafkiasu bazira se na principima opisanim u direktivama EU koje se odnose na gospodarenje otpadom, a uključuju:

- Zaštitu okoliša i poboljšanje kvalitete života,
- Zaštitu ljudskog zdravlja od štetnog djelovanja koje uzrokuje gospodarenje otpadom,
- Sprečavanje nastanka, recikliranje i obrada otpada,
- Ekstrakcija sirovina i energije obradom otpada,
- Odlaganje otpada bez opasnosti za vodu, zrak, tlo, biljke i životinje, bez smetnji poput buke ili mirisa i bez nepovoljnog utjecaja na krajolik ili područja od posebne važnosti i
- Princip onečišćivač plača prema kojemu troškove obrade otpada snosi proizvođač otpada.

Glavni cilj ovog postrojenja je pomoći komunalnim tvrtkama i zajednicama u regijama Larnaca i Ammochostos u gospodarenju otpadom koji nastane u ovim regijama. Provedba projekta također je jedna od obveza prema Strateškom planu za gospodarenje komunalnim otpadom Cipra (2003).
Postrojenje je konstruirano za prihvaćanje miješanog komunalnog otpada, a locirano je u području Nafkias koje pripada zajednici Kochi u regiji Larnaca na jugoistočnom dijelu Cipra. Na ovome području obitava

200.000 stanovnika, a broj se povećava u vrijeme turističke sezone, tako da se godišnje proizvede oko 176.000 tona otpada.

2.1. Postrojenje za mehaničko biološku obradu

Ovo postrojenje uključuje sljedeće jedinice:

- Jedinica za kontrolu i vaganje vozila koja ulaze i izlaze
- Prijam otpada i jedinica za opskrbu sustava za odvajanje otpada
- Postrojenje za mehaničku separaciju i ručno sortiranje
- Objekt za zbijanje i baliranje papira, plastike, željeznih metala i aluminija
- Jedinica za skladištenje oporabljenih materijala
- Jedinica za kompostiranje oporabljenih organskih materijala
- Jedinica za skladištenje, dozrijevanje i standardizaciju proizvedenog komposta
- Jedinica za oplemenjivanje komposta

Figure 1: Postrojenje za cjelovito gospodarenje otpadom u Nafkiasu, Općina Kochi, Područje Larnaca CYPRUS

Postrojenje za mehaničku obradu otpada kombinira sustav otvaranja vrećica za otpad, prosijavanje, odvajanje metala (FE & AL) kao i optičko sortiranje sa bliskim infracrvenim (NIR) sortirkama, separatorima, s ciljem da se od postojeće frakcije dohvati što veća količina recikliranog materijala visoke kakvoće i odvoji organski materijal. Organski materijal otprema se na biološku obradu, a reciklirani materijali do jedinice za recikliranje. Materijali odbačeni tokom procesa odlažu se na odlagalište. Organska frakcija iz miješanog komunalnog otpada se odvaja i konačno tretira u kompostani. Sortiranje i kompostiranje su automatizirani procesi koji se provode u zatvorenim prostorijama bez primjetne emisije neugodnog mirisa ili polutanata u okoliš.

Kompostana radi na principu negativnog sistema aeracije (usisavanje zraka), što znači da je zrak usisan kroz cijevi u zemlji. Onečišćen zrak nastao kompostiranjem, sagorijeva pod visokom temperaturom izgaranja pomoću „LARA“ sistema. Jedinica za sazrijevanje projektirana je kao niz trapezoidnih redova u kojima je omogućena aeracija. Razlog za takav sustav je postizanje visokog stupnja kakvoće završnog komposta i male potrošnje energije. Najveća korist kompostiranja je dobivanje komposta koji se upotrebljava kao umjetno gnojivo ili kao dodatak za kultiviranje tla. Ostaci koji nastaju nakon obrade odlažu se na sanitarno odlagalište, koje se nalazi unutar granica IWM postrojenja, prema specifikacijama Direktive.

2.2 Mehanička separacija/Oporaba materijala i postrojenje za ručno sortiranje (MRF)

Postrojenje za oporabu materijala obrađuje materijale za recikliranje dopremljene iz MBO postrojenja kao i reciklirani materijal dobiven iz programa odvojenog skupljanja na mjestu nastanka. Frakcija otpada prolazi kroz sustav za otvaranje vrećica nakon čega se odvaja prvom i drugom fazom u bubnju za

prosijavanje otpada. Zatim se ubacuje u balistički separator gdje se dalje dijeli u “teške ili kotrljajuće predmete” i “lagane ili ravne predmete”.

Najteži dijelovi frakcije prevoze se pokretnom trakom koja se nalazi u bazi balističkog separatora. Prvo se vode do prvog NIR separatora kako bi se izdvojio PET i ostale vrste plastičnih boca, a zatim do drugog NIR separatora za izdvajanje miješanog papira ili PE/PP plastike, ovisno o želji. Tokovi proizvoda koji su razdvojeni pomoću NIR separatora skupljaju se transporterom koji vodi do kabine za ručno odabiranje 'kontrole kvalitete' koja se nalazi u glavnoj zgradi za mehaničku separaciju te do stroja za baliranje proizvoda, dok tok neželjenih materijala vodi do kontejnera za sakupljanje i od tamo na odlagalište.

Lagani materijal iz balističkog separatora odvode se transportnom trakom do NIR separatora podešenog za razdvajanje plastičnih “filmova” i PVC-a. Ostatak prolazi kroz drugi NIR separator za izdvajanje papira i kartona. Ostatak ovog toka čini gorivo iz otpada (RDF) koje prolazi kroz kabinu za ručno odvajanje kako bi se oporabili i preostali materijali koji se mogu reciklirati (Al i Fe). Nakon toga odlaze na stroj za baliranje.

Tok laganih materijala iz balističkog separatora preostalog nakon prvog NIR separatora podvrgnut je drugom NIR separatoru za obnavljanje plastičnih filmova i uklanjanje PVC-a i drugih mješavina. Plastični filmovi prolaze kroz kabinu za ručno odvajanje i nakon toga do stroja za baliranje dok se preostali 'ostaci' odnose u kontejnere za sakupljanje za odlaganje na odlagalište. Tok materijala iz lake frakcije iz balističkog separatora nakon drugog NIR separatora i nakon izdvajanja papira i kartona podvrgnut je drugoj NIR separaciji pri čemu se izdvaja karton. Karton i papir se odvode do kabine za ručno odvajanje, gdje se još izdvajaju papir za printanje i ostali papir. Neželjeni ostaci iz kabine za ručno odvajanje odvode se u kante za sakupljanje za odlaganje na odlagalište.

Materijali za recikliranje iz programa „izdvajanje na mjestu nastanka“ također se dostavljaju u zgradu za mehaničku separaciju, gdje se odvajaju i baliraju. Između zgrade prijama otpada i zgradu za mehaničku separaciju postoji posebno dodijeljeno područje na kojem se istovaruju materijali skupljeni na mjestu nastanka. Ti materijali mogu stići ili u miješanoj formi (iz sistema 'plave kante') ili već odvojeni po vrsti. Izmiješani reciklirani materijali prolaze kroz sistem mehaničke separacije kroz posebno određeni ulazni odjeljak, odakle sustav može obraditi ove materijale kao i odvojeni 'čisti' otpadni tok (bez organskih tvari) proizvodeći visoko kvalitetne proizvode.

Slika 2: Postrojenje za reciklažu otpada u Nafkias, Općina Kochi, Područje Larnaca CYPRUS

2.3. Kompostana

Glavna korist od kompostiranja je da se glavni produkt (kompost) može upotrebljavati kao umjetno gnojivo ili kao dodatak za kultiviranje tla. Ovaj je sistem odabran jer postiže visoku kvalitetu finalnog komposta u kratkom vremenu s niskom razinom potrošene energije. Intenzivno kompostiranje u potpunosti je automatizirano i odvija se u potpuno zatvorenim objektima s kontroliranom atmosferom bez primjetnih emisija neugodnog mirisa ili polutanata u okoliš, gdje se onečišćeni zrak tretira spaljivanjem na visokim temperaturama pomoću patentiranog „LARA“ sistema koji je proizvela tvrtka Herhof GmbH.

U kompostani se obrađuje zeleni otpad koji uključuje otprilike do 23.920 tona/godišnje odvojene organske frakcije komunalnog otpada (iz postrojenja za mehaničku obradu) te 16.000 tona/godišnje organskog materijala koji se skupi programom „Odvajanje na mjestu nastanka“, što je izračunato iz ukupnog kapaciteta jedinice za mehaničku i ručnu separaciju. Kompostana radi na principu negativnog sistema

aeracije (usisavanje zraka), što znači da se zrak isisava kroz kompost do aeracijskih cijevi u tlu, što uvelike smanjuje stvaranje i disperziju prašine i neugodnog mirisa.

Organski materijal skupljen „Odvajanjem na mjestu nastanka“ dostavlja se na ranije određenome prekrivenome području izvan kompostane, odakle se unosi u usitnjivač, a zatim putem transportne trake do automatski odabranih kompostnih boksova. Organska frakcija iz komunalnog otpada dolazi od postrojenja za mehaničku separaciju u kompostanu putem transportne trake koja povezuje dvije zgrade odakle se također transportnom trakom unosi do automatski odabranih kompostnih boksova. Dva toka organskog materijala drže se odvojeno, te materijal skupljen odvajanjem na mjestu nastanka stvara kompost kategorije A, dok organska frakcija iz komunalnog otpada stvara kompost kategorije B. Nakon što ostanu u zatvorenim boksovima u razdoblju do 10 dana, postojeći materijali su u potpunosti obrađeni te se tada premještaju u vanjsku prekrivenu prostoriju za sazrijevanje kako bi se stvorile kompostne hrpe. Hrpe se tada u periodu u pet tjedana povremeno preokreću i vlaže pomoću specijaliziranog vozila kako bi se dovršio stabilizacijski proces. Ovdje završava sazrijevanje komposta.

Nakon sazrijevanja, kompost dobiven od dvije odvojene kategorije odvozi se u prostor za pročišćavanje komposta gdje se prosijavanjem uklanjaju nečistoće. Ovaj se dio sastoji od dvije odvojene produkcijske linije, jedne za svaku kategoriju komposta. Otprilike petnaest posto (15%) proizvedenog komposta (prednost je dana kompostu A kategorije) pakira se u vreće koje se skladište na paletama i omataju plastičnom folijom i kao takve pripremaju za dostavu. Preostalih osamdeset i pet posto (85%) proizvedenog komposta skladišti se u trokutastim hrpama u natkrivenom vanjskom području kako bi se koristio za prekrivanje odlagališta ili slično.

2.4. Sanitarno odlagalište otpada

Ukupna površina sanitarnog odlagališta iznosi 113 hektara a sagrađena je u dvije faze te je ukupnog kapaciteta 2,8 milijuna m^3. Površina odlagališta projektiranja je kako bi bila u funkciji 20 godina, što je izračunato korištenjem radnog kapaciteta od 88 000 tona/godini od ostataka iz susjednih MBO postrojenja.

Osnovna infrastruktura na odlagalištu je slijedeća:

- Brtvljenje: Za čvrst i jak temeljni sloj i povećanje zaštite područja korišten je složeni sustav brtvljenja;
- Mreža cijevi za prikupljanje procjednih voda: Prikupljanje procjednih voda u svakoj stanici odvija se pomoću mreže potopnih pumpa i HDPE cijevi:
- Instalacija za obradu procjednih voda: Obrada procjednih voda provest će se u dvije faze. Prva faza uključuje prvi korak obrade aeracijom i precipitacijom suspendiranog materijala a druga faza uključuje daljnju obradu reverznom osmozom.
- Postrojenje za skupljanje i spaljivanje bioplina: U svakoj fazi razvoja sanitarnog odlagališta paralelno s odlaganjem ugraditi će se sustav cijevi za sakupljanje bioplina. Skupljeni plin u budućnosti bi se mogao iskoristiti za dobivanje energije.

3 Rezultati i diskusija

Postrojenje za cjelovito gospodarenje otpadom u Nafkias koristi 200.000 stanovnika. U vrijeme turističke sezone u regijama Larnaca i Ammochostos dolazi do porasta broja ljudi što rezultira godišnjom količinom ptoada od 176.000 tona (160.000 tona/godišnje komunalnog otpada i 16.000 tona/godišnje zelenog otpada)

Prosječni kapacitet postrojenja za mehaničko odvajanje miješanog otpada iznosi 160.000 tona/godišnje, ili, budući da će raditi 6 puta tjedno po 14 sati dnevno (dvije smjene): 516 tona/dnevno ili 40 tona/hr (u obzir nisu uzete količine materijala skupljenog programom Odvajanje na mjestu nastanka). Rezultat uključuje dvije linije obrade, svaka s prosječnim kapacitetom 20 tona /satu.

Kompostana obrađuje organski materijal koji je oporabljen u postrojenju za mehaničko odvajanje. U suštini, postrojenje za kompostiranje obrađuje organski otpad koji je izdvojen na postrojenju za mehaničko sortiranje otpada. Uz pretpostavku da će se reciklirati 65 % organskog otpada iz komunalnog otpada, kapacitet postrojenja iznosi 0,65 X 0,23 X 160.000 t/g = 23.920 t/g, uvećano za 95 % od 16.000 t/g zelenog otpada skupljenog putem sustava za odvojeno skupljanje otpada na mjestu nastanka. Dakle, ukupni kapacitet je procijenjen na 23.920 + (95% x 16.000) = 39.120 t/g or ≈125 t/dan (uz pretpostavku 6 radnih dana u tjednu).

Tablica 1: Oporabljeni materijal iz postrojenja za oporabu materijala (uz projektirani kapacitet od 176.000 t/god te bez odvajanja otpada na mjestu nastanka)

SASTAV	Sastav (% p.w.)	Količina (t/godišnje)	Stopa oporabe	Oporabljena količina (t/ godišnje)	Ostaci (t/ godišnje)
Komunalni otpad					
Putrecibles	25.28	40.480	65%	26.312	14.168
Papir	30.77	49.280	45%	22.176	27.104
Plastika	17.58	28.160	45%	12.672	15.488
Staklo	2.20	3.520	45%	1.584	1.936
Željezo	3.30	5.280	70%	3.696	1.584
Aluminij	1.1	1.760	70%	1.232	528
Tekstil, koža, drvo, guma	9.90	15.840			15.840
Ostalo	9.9	15.840			15.840
	100,00	*160.160*		*67.672*	*92.488*
Zeleni otpad		15.840	95%	15.048	792
UKUPNO	**100%**	**176.000**		**82.720**	**93.280**

3.1. Konačni rezultati

Prema gore navedenim dimenzijama postrojenja i tehničkim karakteristikama, slijedeća tablica pokazuje prosjek (rad sa 160,000 t/godišnje miješanog komunalnog otpada) i maksimalne (rad sa 200,000 t/godišnje miješanog komunalnog otpada) količine oporabljenih proizvoda.

Tablica 2: Produkti koji nastaju u postrojenju

Proizvodi	**Prosjek oporabljenih proizvoda (t/dan)** - 160,000t/god MKO	**Maksimum oporabljenih proizvoda (t/dan)** - 200,000t/god MKO
Kompost iz miješanog otpada	59,3 t/dan	74,05 t/dan
Kompost iz odvojeno skupljenog zelenog otpada	17,88 t/dan	17,88 t/dan
Ispisani papir	20,31 t/dan	25,36 t/dan
Miješani papir	72,31 t/dan	90,45 t/dan
Karton	21,94 t/dan	27,40 t/dan
RDF	28,26 t/dan	35,29 t/dan
Plastika	39,06 t/dan	48,78 t/dan
PET	2,78 t/dan	3,47 t/dan
PE/PP	12,09 t/dan	15,09 t/dan
Željezo	17,73 t/dan	22,14 t/dan
Aluminij	4,53 t/dan	5,66 t/dan
Staklo	5,17 t/dan	6,45 t/dan
Ostaci	167,2 t/dan	207,33 t/dan
Ukupno	**468,6 t/dan ili 145,266 t/god**	**579,4 t/dan ili 180,750 t/dan**

3.2. Obrada otpadnih voda

Otpadne vode u postrojenju nastaju u jedinici za kompostiranje, na odlagalištu (kao filtrat i kondenzat iz bioplina), u jedinici za pranje i servisiranje te u kanalizaciji. Osim iz postrojenja za kompostiranje, otpadne vode koje nastaju unutar jedinice obrađuju se u centralnom dijelu za obradu otpadnih voda. Iduća tablica pokazuje količinu i porijeklo nastalih otpadnih voda.

Tablica 3: Vrsta i porijeklo nastalih otpadnih voda prije obrade i/ili miješanja

Vrsta i porijeklo nastale otpadne vode	**Količina**	
	m^3/dan	**m^3/ έτος**
Procjedne vode sa odlagališta	130	40.300

Otpadne vode iz kompostane	27	8.370
Vode za čišćenje, kanalizacijske vode, kondenzat iz mreže za bioplin….	35	10.850
Ukupna količina otpadne vode	192.0	59.520

Uređaj za obradu otpadnih voda kompostane – Unutar mreže zračnog strujanja u kompostani iz izlaznog zraka zatvorenih kompostnih boksova stvara se kondenzat. Kondenzat zatim odlazi u poseban uređaj za obradu otpadnih voda gdje se nakon obrade čista voda ponovo upotrebljava kao dodatak vodi za hlađenje u tornju za hlađenje. Korišteni sistem za obradu je MBR (membranski bioreaktor), koji ima malu površinu, a veliku učinkovitost. Uključuje suspendirani rast aktivnog mulja, korištenjem ultrafiltracijskih membrana, zbog čega ne treba poseban sedimentacijski bazen. Sistem je kompaktno projektiran, što omogućuje stvaranje obrađene vode pogodne za ponovnu upotrebu u kompostani. Uređaj za obradu otpadnih voda iz kompostane može se zaobići (na primjer u slučaju kvara ili popravaka) pa se otpadne vode mogu usmjeriti u kanalizacijsku mrežu, i od tamo u centralnu jedinicu za obradu otpadnih voda sa odlagališta. Otpadne vode nastale u procesu kompostiranja cirkuliraju kroz sustav, te nema potrebe za njihovim posebnim zbrinjavanjem.

Uređaj za obradu otpadnih voda sa odlagališta- Obrada otpadnih voda prikupljenih na odlagalištu (procjedne vode i kondenzat iz sustava za skupljanje bioplina) te iz postrojenja za servisiranje i pranje vozila i operativnog centra odlagališta (sanitarne otpadne vode) vrši se u centralnoj jedinici postrojenja za obradu otpadnih voda odlagališta. Projektirano je da primi 130 m^3/d procjednih voda iz odlagališta, i dodatno 35 m^3/d iz drugih izvora. Jedinica za reverznu osmozu sa kapacitetom od 200 m^3/d, koja se sastoji od dva dijela, može zadržati sve makromolekule, 2+ nabijene ione ili veće mikrobiološko opterećenje. Koncentrat iz reverzne osmoze (40% obrađenih voda) odlazi u spremnik, dok čista tekućina nakon prolaska kroz sustav za otplinjavanje odlazi u spremnik s čistom vodom. Jedinica je konstruirana da bude dovoljna za ukupnu proizvodnju procjednih voda sa odlagališta i sa malom koncentracijom polutanata ($BOD_5 \leq 20$ mg/l, N≤ 15 mg/l, COD ≤150 mg/l) pružajući visoku razinu fleksibilnosti i adaptacije na bilo kakve promjene protoka i onečišćenja. Pročišćena tekućina koristi se za navodnjavanje unutar postrojenja za gospodarenje otpadom, dok se preostali dio vraća na odlagalište. Svi polutanti filtriraju se u jedinici za reverznu osmozu, koja je projektirana da bude pogodna za obradu svježe procjedne vode.

Tablica 4 Vrsta i količina obrađene otpadne vode za ispust

Vrsta i nastanak obrađene otpadne vode	**Količina (m^3/dan)**	**Nastanak**
„Ostaci“ iz procesa reverzne osmoze	66	Recirkulacija unutar tijela odlagališta
Čista voda dobivena iz procesa reverzne osmoze	99	Površinsko natapanje postrojenja
Ukupna količina ispuštene (obrađene ili neobrađene) otpadne vode	165	

3.3. Količina nastalog krutog otpada i mulja

Postrojenje stvara minimalnu količinu krutog otpada zahvaljujući:

a) Mulj iz spremnika za taloženje, posebno osušeni mulj iz vrećastog filtera i
b) Prašina prikupljena iz raznih filtera za zrak unutar postrojenja (uglavnom iz prijemne zgrade i zgrade u kojoj se odvija mehanička separacija). Skuplja se pomoću vrećastog filtera u odgovarajuće vreće.

Gore navedeni kruti otpad se ne iskorištava dalje nego odlaže na odlagalište.

4 Zaključak

MBO postrojenja imaju značajnu ulogu u „sekundarnoj fazi recikliranja“. Čak i kad lokalne vlasti imaju dobro razvijen sustav skupljanja po kućanstvima, MBO omogućuje povećanje stope recikliranja otpada čime se smanjuje količina na odlagalištu. Smatra se da neki MBO sistemi mogu oporabiti 15-20% ostatnog otpada nakon recikliranja na mjestu nastanka. Također, kvaliteta recikliranih metala dobivenih MBO-om veća je nego nakon spaljivanja i time ima veću vrijednost. Odlaganje materijala preostalog nakon mehaničko-biološke obrade ima brojne prednosti naspram odlaganja neobrađenog otpada, prvenstveno smanjeni faktor biorazgradljivosti. Odlagališni filtrati i plinovi smanjeni su na oko 10% od onih nastalih iz neobrađenog otpada. Time se smanjuju troškovi gospodarenja odlagalištem, ali i dugoročne obveze lokacije odlagališta. Nadalje, budući da se masa i volumen otpada smanjuju za 45%, manje se otpada odlaže na samo odlagalište. Također, neki se dijelovi otpada mogu koristiti za

proizvodnju RDF-a, koji tada ima veću kalorijsku vrijednost od one nastale od neobrađenog otpada. Na taj se način iz proizvedenog materijala može iskoristiti energija čime se povećava vrijednost otpada.

U ovoj fazi rada postrojenja za gospodarenje otpadom u regiji još nisu razvijeni programi odvojenog skupljanja otpada na mjestu nastanka koji bi davali značajne rezultate. Zbog toga se u postrojenju trenutno obrađuje samo miješani komunalni otpad. Kako će se poboljšavati programi odvojenog skupljanja otpada na mjestu nastanka, postotak materijala iz ovog izvora će se povećavati, usporedno sa smanjenjem količina miješanog komunalnog otpada budući da predodređeni dio otpada čini postotak miješanog komunalnog otpada. Prilikom projektiranja postrojenja uzeta je u obzir i ta mogućnost te je omogućena njegova brza prilagodba ovisno o količinama i vrstama ulaznog otpada iz sustava za odvojeno skupljanje otpada, podešavanjem radnog kapaciteta postrojenja na dvije odvojene linije za obradu otpada.

Inovativna kvaliteta postrojenja je da može podnijeti i mješoviti i odvojeno skupljeni materijal te istodobno proizvesti kompost i gorivo iz otpada te stoga da ima visoki postotak fleksibilnosti i lako se može prilagoditi promjenama u sastavu gospodarenja otpadom ali i budućim zahtjevima tržišta za krajnje produkte.

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