Resource efficiency and cleaner production in the olive oil industry

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Abstract

Aim: The olive oil industry generates big amounts of by-products: pomace and waste water that may result in very negative environmental impacts if there are no accu-rate management strategies. The Cleaner Production (CP) is a continuous application of an inte-grated preventive environmental strategy applied to processes and prod-ucts to increase efficiency and reduce risks to humans and the envi-ronment. This study was carried out to demonstrate the application of Cleaner Production Technology in the olive oil industry.
Methods: The CP demonstration was carried out during the period 2011-2012, in an olive oil mill. The methodology used for conducting on-site evaluation of the CP included: i) pre-assessment of the company (description of the company and the processes, input-output analysis through in-terviewing staff of the company); ii) material and energy flow analysis, with the aim to identify pollution sources and the related pollution causes; iii) option generation and feasibility study from technical, economic and environmental view, identification of feasible measures, and; iv) implementation of feasible measures by the company and monitoring of the achieved effects.
Results: The identified CP measures included the following: development of the information system, monitoring and saving of water consumption, improvement of the quality of olives, process modification: installation of the sec-ond centrifuge in the oil cleaning process, processing the pomace to be used as fuel (drying and pressing of the pomace), treatment of waste waters before discharging into municipal sewage system (op-tional treatment system "reed bed system" or "constructed wet-land").
Conclusion: This study demonstrates how CP can be implemented successfully in the olive oil industry using efficiently the available resources.

Keywords: cleaner production, economic and environmental ben-efits, olive oil, pomace, waste waters.

Introduction

The olive oil sector is an important segment of the Albanian agro-industry. There are 130 processing mills and their average size in terms of volume of processed olives per year is small, between less than 100 and 1,500 t/ year (1). Regarding the extraction technology, most of mills apply three-phase centrifugation system and only two use dual phases. *The olive oil industry generates big amounts of by-products: pomace and wastes water that may result in very negative environmental impacts if there is not an accu-rate management strategy (2). The* Cleaner Production is the continuous application of an integrated preventive environmental strategy applied to processes and products to increase efficiency and reduce risks to humans and the environment (3). Resources (water, energy and raw material) can be used more efficiently thus reducing at the same time losses and environmental pollution and improving health and safety. Economic profitability together with environmental improvement is the aim of CP. The *CP demonstration was carried out in the olive oil mill, called "Musaj Olive Oil" in the V lora, which* mostly provide to farmers the service of processing olives into olive oil, against a fee (80%) and produces and trades "organic olive oil" and "extra virgin olive oil" (20%) for itself. It applies continuous three phase centrifugation system and the production is seasonal from October to March. In 2011-2012 was processed 520 t olives, when 100 t for company itself and 420 t for farmers.

The company has a good performance regarding the food safety & quality, it produces and trades the best categories "organic olive oil", "extra virgin olive oil" and "virgin olive oil, but doesn't know the environmental legislation although it is aware about negative environmental impacts of the olive oil industry. *In order to improve its environmental performance and to increase economic profitability the company decided to join us in this CP study.*

The aim of this study is to demonstrate how Cleaner Production (CP) can be implemented in the olive oil industry, thus increasing the economic profitability together with environmental improvement. By the extraction process of oil, the following non products outputs are obtained (5): *Vegetable waters* or waste waters, made up of the vegetable waters of the olives mixed with water added in the process, relatively in high amounts (approximately 1L/ 1 kg of olives processed) with high organic loads. These highly polluted waste waters are not treated and are discharged into municipal sewage system (6).

The *pomace* or solid waste, which is discharged in open area, causes environmental pollution and contamination of the final product (olive oil).

We performed the in site visit in the company during operation, when we took photos and collected the data on process, materials, water and energy consumption. Then we carried out a material and energy flow analysis with goal to identify pollution sources and related pollution causes.

After the evaluation were identified eight CP options for improvement, mainly related to water consumption, optimize the process and reusing of solid waste (*pomace*).

Among these options, seven were selected for feasibility study as following: Development of the information systems; Installation of water meter for total consumption and for washing process; Reducing the water capacity of washing machine, Improvement of quality of olives; Pavement of the outside part, where is discharged the *pomace* and covering of waste water channel, Installation of the second centrifuge in the oil cleaning process, Processing the *pomace* to be used as fuel.

Six of above CP measures were implemented until on March 2013 (Table 3).The benefits of the implementation of the CP measures were: reducing the water consumption, reducing the waste water and its pollution load, increasing the production efficiency and quality of olive oil. This study demonstrates how CP can be implemented successfully in the olive oil industry using efficiently the resources.

Material and Methods

The CP is the continuous application of an integrated preventive environmental strategy applied to processes and products to increase efficiency and reduce risks to humans and the environment. Resources (water, energy and raw material) can be used more efficiently thus reducing at the same time losses and environmental pollution and improving health and safety. Economic profitability together with environmental improvement is the aim. CP

typically includes measures such as "good housekeeping", process modifications and control, input material change, on-site recycling or recovery, production of useful by-products or product modification.

The demonstration of application of the CP was carried out, in the olive oil mill, called *"Musaj Olive Oil"* which operates in Vlora. The period of study was from November 2011 to March 2012 and monitoring of implemented measures during the 2013.

The methodology of CP Audit follows the following steps:

1) Pre-assessment (forming of the CP-team, description of the company and the processes, input-output analysis, setting up baseline - the baseline data for key performance indicators for selected priority area(s).

2) Material and energy flow analysis with goal to identify pollution sources and related pollution causes.

3) Option generation and feasibility study - generation of CP options based on the understanding of pollution causes and their evaluation from technical and organizational point of view as well as from the economic and environmental perspective.

4) Implementation of feasible measures by the company and monitoring of achieved effects.

Results

The general input-output analysis was performed for the whole company (Table 1), enabling us to set up the priority areas to estimate potential for improvement, respectively: Raw material (olives) and water consumption. In Table 1 are presented data for key input such as olives, water and energy and non product output, such as waste waters and *pomace* which were not turned into desired products, but appear as process losses.

Table 1. General input-output analysis for the whole company

Input	Annual consumption	Unit cost (€)	Annual costs(€)	Included in product (%)	NPO (%)	NPO cost (€)	Total NPO costs (€)
olives	520 ton	714	371429	20% oil			
					40 % *pomace*	148572	148 572
					40% waste water	148572	148 572
water	643 m^3	0.5	330		100% waste water	330	330
energy	31250 kWh		1786				1786
Fuel	20 m3	7.1	142				142
Cleaning agents (caustic soda)			114				114
Packages materials: Plastic contains 6 L Bottles ½ L Carton boxes	 3000 400 100 piece		172,9				
Labels	500 piece						
Filter	10 pack						

NPO – Non product output – input materials, water and energy which were not turned into desired product (appears as losses, pollution and waste flows)

Diagram 1 presents a flowchart of the industrial process with the aim to identify pollution sources and the related pollution causes.

Diagram 1: General outline of the industrial oil mill process

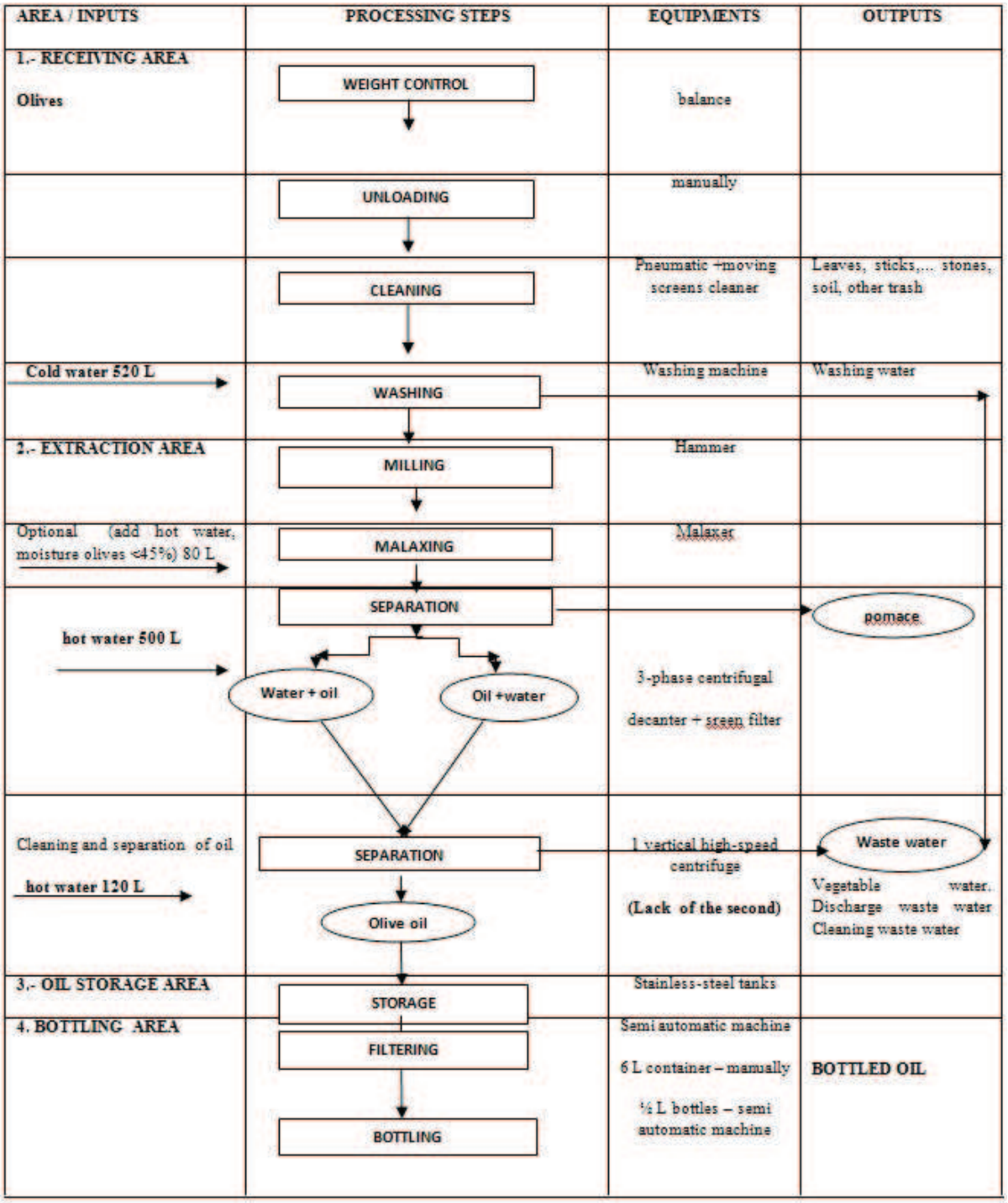
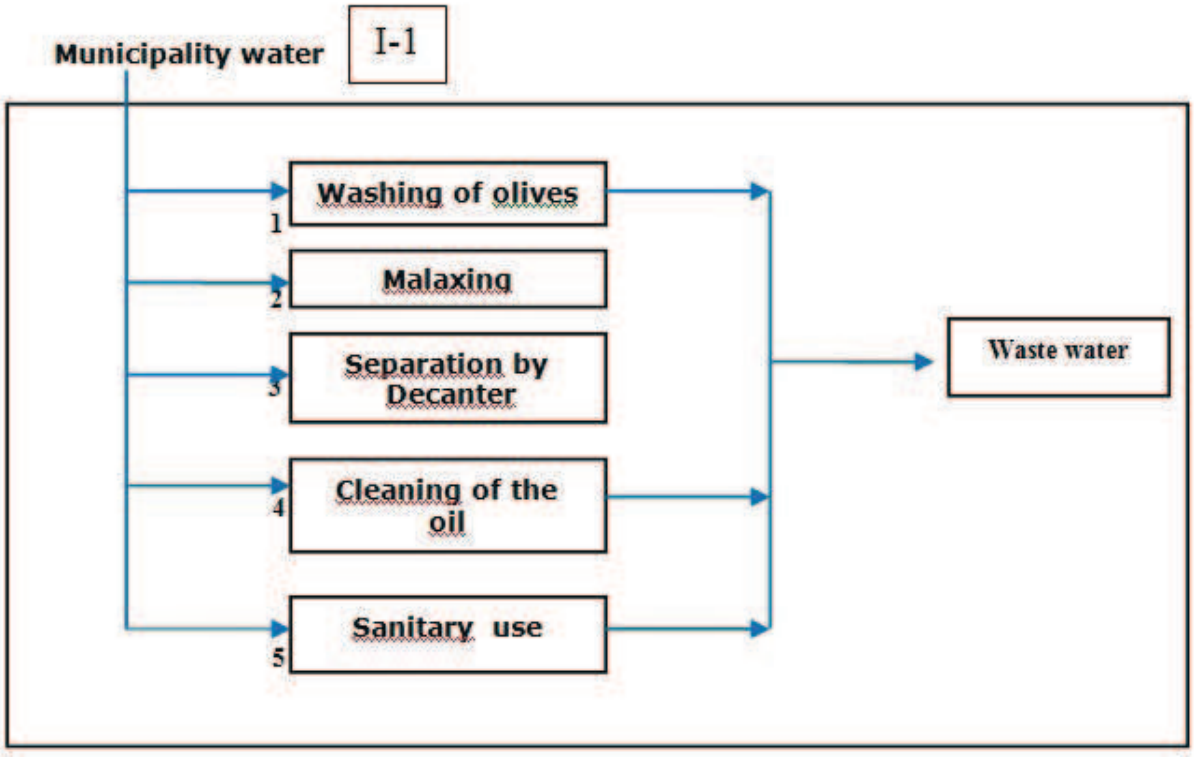


Diagram 2. Flowchart for water



Worksheet: Water data sheet

Balance scope: **Entire company** Balance period: **2010** Company: **"Musaj Olive oil"**

No.[1]	Water input	Quantity	Unit[2]	Data source[3]/notes
I-1	Potable water (Municipality water)	40	m³	Water bill (without metering)

No.[1]	Water consumption	Quantity	Unit[2]	%	Data source[3]/notes
1	Washing of olives	270,4	m³	42	Calculated
2	Malaxing	41,6	m³	6.3	Calculated
3	Separation by decanter	260	m³	40	Meter and calculated
4	Cleaning of oil	62,4	m³	9.7	Calculated
5	Sanitary use	18	m³	2.7	Calculated
	Total	643.4		100	

No.[1]	Water output	Quantity	Unit[2]	Notes
	Wastewater discharge O direct x indirect	759	m³	Important materials: Important limit values: **COD, BOD, T, pH** Description of on-site wastewater treatment:

[1] = Position no. from flowchart 3-1 [2] = Balance in m³ not precise (general assumption: density 1 kg/l)
[3] = EDP, books, routine measurement, own measurement, information from production, documentation of equipment, calculation, estimate, etc.

The contamination load of the waste water before and after the implementing the CP measures is shown in Table 2.

Table 2. Waste water contamination load

Indicators	Unit	Before the CP implementation	After the CP implementation	National Norms
BOD_5	mg/l	2950	1577	50 mg /l
COD	mg/l	4600	2320	250 mg/l

Based on the general input-output analysis for the whole company were set up the priority areas for improvement and were performed the fea-sibility study for CP generated options. The CP measures identified and their feasibility study and implementation are shown in the Table 3.

Table 3. The feasible CP measures identified in the olive oil

Measures	Cost for implementation	Economic benefits	Environmental benefits	Implementation
Establishment of the information system	500 €	Better management and planning the activity	Better management and monitoring of wastes	implemented
Installation of water meters	100 €	Saving and using efficiently the water	Reduction of waste water and its pollution load	implemented
Pavement of the outside part, where is discharged the *pomace* and covering of waste water channel	7142 €		Minimize the environmental pollution and avoid oil contamination from foreign odors.	implemented
Reducing the water capacity of washing machine (Filling in a smaller volume 1500 L / 8 hour by 2000 L /8 hour)	No investment needed	Reduction of the water consumption	Reduction of the waste water	implemented
Improvement of quality of olives		Reduction of the water consumption, improving the production efficiency and quality of oil	Reduction of the waste waters and its pollution load	implemented
Installation of the second vertical centrifuge in the cleaning oil process	21 000 €	Reduction of the water and energy consumption, Reduction of the Labor costs, Increasing the production efficiency and quality of olive oil	Reduction of waste waters and its pollution load through reduction of the Phenol (water soluble) and residual oil concentration in generated waste water	implemented
Processing the pomace to be used as fuel;	82.400 €	Increase the company profits since the processed *pomace* is very demanded and avoid the cost for manipulation and transport of *pomace*,	Reducing the environmental pollution, oil contamination and saving the natural source (energy) by reusing efficiently the by product (*pomace*).	not yet, it is an long term measure
Pre treatment of waste water, before discharging into municipal sewage system.	To be decided after identification of the commercially used alternative		Minimizing waste water pollution load: Reducing the environmental pollution	not yet, it is an long term measure

Discussion

The general input-output analysis in Table 1 shows that the main input are olives, from which are generated greater process losses or wastes, where the only 20 % of olives are returned into the product, while 80% are losses, respectively 40% *pomace* and 40% vegetable waters.

By the input output analyses we have identified *the raw material (olives) as a priority area* for detailed analyses and defining the CP measures. The raw material (olives) should be analyzed in all its processing cycle, from quality of olives up to non products obtained from its processing (waste water and *pomace*) which constitute the major process losses. Regarding the water, it is used in considerable

amounts in the production processes, respectively in the washing, malaxing, extraction and cleaning of oil. The water added in the process, is considered 100 % waste waters and source of environmental pollution, so we have identified *the water consumption as priority* area for detailed analyses and defining the CP measures for improvement.

The detailed analyses of the water consumed is shown in the Diagram 2 and worksheet, where is resulted that are consumed large amounts of potable water. The water input (municipality water, it isn't metered, because there isn't any installed water meter), so the amount of water billed it isn't equal to the water actually consumed.

The water datasheet, regarding the water consumption and waste water discharged, were collected and calculated, by in site survey with help of very experienced manager. So, we defined as CP: Installation of water meter for total consumption and for washing and rinsing process *(see table 3), since in this process are consumed large amounts of water (42%). Also, in the washing process are used large amounts of water because of poor quality of olives brought by farmers. In order to save the washing water we defined as CP:* Improvement of quality of olives (see table 3). The Cleaning and rinsing process is closed cycle. The washing machine usually is filled in volume 2000 lit/ 8 h or 6 ton and the dirty water is discharged. Also in this process is consumed fresh water for rinsing of olives. During the washing process the water overflow so are discharged 80 lit/ ton. In order to manage efficiently the water, we have identified the *CP: Reducing the water capacity of washing machine; filling it in a smaller volume 1500 lit/8 hour.* By implementing this measure was saved 80 lit / ton or 41600 lit/ yr water (see table 3).

The main wastes generated in the olive oil mill are waste waters and solid waste (*pomace*). The processing of olives produces relatively high amounts of vegetable water (approximately 1lit/ 1 kg of olives processed). The contaminated load of the waste waters, analyzed in the Public Health Institute have resulted highly polluted before and after implementation of the CP (see table 2). As the waste waters are discharged into municipal sewage system without any treatment, we suggest the optional *CP: Pre treatment of waste water before discharge* into municipal sewage system. By the literature (UNEP, Regional Activity Center for Cleaner Production 2000: Pollution prevention in olive oil production), are listed some alternatives on waste water treatment, when we suggest as appropriated the "reed bed system" and "constructed wetland"). Solid waste (*pomace*) is in considerable amounts and it is discharged into the open area out of the premise. The *pomace* is considered as process losses, so its processing will be profitable for the company, from economical and environmental point of view. The most of the amounts of the *pomace* is sold to use as feedstock (fresh) and as fuel, against a modest fee, but if it processed it would be more profitable for the company. The CP is: *The processing the pomace to be used as fuel (see table 3).*

As shown in Diagram 1, the current process of separation and cleaning of oil, is made by one vertical centrifuge, instead of two as required by three phase decanter technology. *So we have identified this CP option: Installation of the second vertical centrifuge in the cleaning of the oil process.*

This process modification CP measure, despite its high cost, has been implemented immediately, because of the numerous benefits derived from its implementation (see Table 3), such as improving the mill oil recovery efficiency, increasing the production efficiency, reducing the water and energy consumption, improving the quality of oil and reducing the waste waters and its pollution load through reduction of the Phenol (water soluble) and residual oil concentration in generated waste water.

Conclusions

Recognition and implementation of Cleaner Production Technology by the food business operators in the food industry and in the olive oil industry particularly, is very important for its environmental and economic benefits.

Water consumption in the olive oil industry in Albania is relatively high, there-fore CP measures should be implemented for saving and using the water efficiently, such as "good housekeeping" (monitoring and saving the wa-ter, using the water meters), process modifications (reducing the water con-sumption in washing machine) etc. Using the water efficiently, reduce the waste water and its pollution load.

From the olive oil mills are generated large amounts of the highly polluted waste waters that are

discharged without any pre - treatment into municipal sew-age system. By literature many options are proposed for treat-ment of olive mill waste waters such as "reed bed system" or "constructed wetland", but their complexity, high capital and operation costs, are limiting factors on the identification and implementation of efficient treatment options.

In this context we recommend as necessity building capacities of the food business op-erators and CP national experts, on identification and implementation of the most efficient options for treatment of waste water.

Regarding the technology used in olive oil production, by literature is recommended that dual phase centrifugation system is the best from the environmental point of view, but this study reports that the three phase centrifugation technology can be used efficiently in small mills (most of mills in Albania are small), if an appropriate management system is put in place for the solid waste (*pomace*), minimizing the environmental pollution.

We recommend that owners of the mills develop a plan for the collection of the *pomace* in the regional level and it's processing for producing the fuel (briquettes). This initiative needs the financial support by foreign agencies such as UNIDO, in order to improve the environmental performance of olive oil mills.

References

1. Studim *"Gjendja aktuale e ullishtarisë dhe perspektiva e zhvillimit të saj"*. Ministria e Bujqësisë Ushqimit dhe Mbrojtjes së Konsumatorit. Tirana, Albania, 2009.
2. UNEP, Regional Activity Center for Cleaner Production. Pollution prevention in Olive oil production, 2000.
3. Regional training: 19-21 March 2012, Greece: *"Best environmental prac-tices in olive mill waste management and new technologies"*. Greece, 2012.
4. Dr. Adnan I. Khdair, PM "Cleaner Production (CP) in Olive Oil Industry in Jordan *"Integrated Waste Management for the Olive Oil Pressing Industries in Lebanon, Syria and Jordan"* UNDP-MoEnv. The 2nd Arab Cleaner Production Workshop, Amman, August 28-30, 2007.
5. National Cleaner Production Programme for Albania 2011. Report of Environmental Centre for Administration and Technology (ECAT) Albania. Tirana, Albania, 2011.
6. Nicolas Kalogerakis. Chania, Crete, Greece LIFE07/ INF/ IT/ 00438 *"Implemented technologies for OMW treatment across the Mediterranean basin The OLEICO + Experience"*. Greece, 2012.
7. Luciano Leonetti, Drini Imami, Andi Stefanllari, Edvin Zhllima. The olive and olive oil value chain in albania .Tirana, May 2009.
8. Magali Outters. Towards Sustainable Consumption and Production in the Mediterranean Region. Regional Activity Center for Cleaner Production, H2020 National Training, Albania 30th of June-1st of July 2011.