USAID FROM THE AMERICAN PEOPLE | JORDAN

INSTITUTIONAL SUPPORT & STRENGTHENING PROGRAM

OLIVE MILLS WASTEWATER (ZIBAR) STUDY FINAL REPORT

October 2013

This report was produced for review by the United States Agency for International Development (USAID). It was prepared by International Resources Group (IRG) for the Institutional Support & Strengthening Program (ISSP).

INSTITUTIONAL SUPPORT AND STRENGTHENING PROGRAM (ISSP)

OLIVE MILL WASTEWATER (ZIBAR) REPORT

October 2013

TABLE OF CONTENTS

ACRONYMS

AD	Anaerobic Digestion
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EIB	European And Investment Bank
FOG	Fat, Oil, And Grease
GAM	Greater Amman Municipality
HRT	Hydraulic Retention Time
JSC	Joint Services Council
MEDOLICO	Mediterranean Cooperation In The Treatment And Valorisation Of Olive Mill Wastewater
OMWW	Olive Mill Wastewater
MOA	Ministry Of Agriculture
MoEnv	Ministry Of Environment
MOH	Ministry Of Health
MOMA	Ministry Of Municipal Affairs
MOPIC	Ministry Of Planning And International Cooperation
MOU	Memorandum Of Understanding
MWI	Ministry Of Water And Irrigation
OLR	Organic Loading Rate
RSS	Royal Scientific Society
SRT	solids retention time
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UASB	Up-Flow Anaerobic Sludge Blanket Reactor
WWTP	Wastewater Treatment Plants
WAJ	Water Authority Of Jordan
ZTP	Zibar Treatment Plant

1. EXECUTIVE SUMMARY

1.1. THE MASTER PLAN FOR ZIBAR

A wastewater master plan was requested by the minister of MWI in the meeting with ISSP on June, 30th 2013. H.E requested a simple master plan that can help MWI to determine investment priorities in wastewater services in Jordan. The master plan would then be used as a tool to help WAJ in their decision making process for capital investment in as WAJ currently has no long term plan for wastewater systems on the national level and priorities are not clearly identified. The wastewater streams to be studied as part of this master plan are: municipal wastewater, industrial wastewater, and olive mill wastewater (Zibar).

This report presents the background and understanding of the status quo in relation to Zibar management in Jordan, the legal and institutional setup, the potential treatment technologies for Zibar, and the recommended options for Jordan.

1.2. BACKGROUND

Olive oil production is one of the main industries in the Mediterranean region. It accounts for about 97% of the worlds olive production. According to the MEDOLICO Project (Mediterranean Cooperation in the Treatment and Valorisation of Olive Mill Wastewater), the Mediterranean region produces yearly around 11 million tons of olives, out of which 2 million tons olive oil is extracted. This production of olive oil generates about 9 million tons of waste each year in olive oil producing countries. If not well managed, this waste can cause serious environmental degradation.

1.2.1. GENERATION OF ZIBAR IN JORDAN

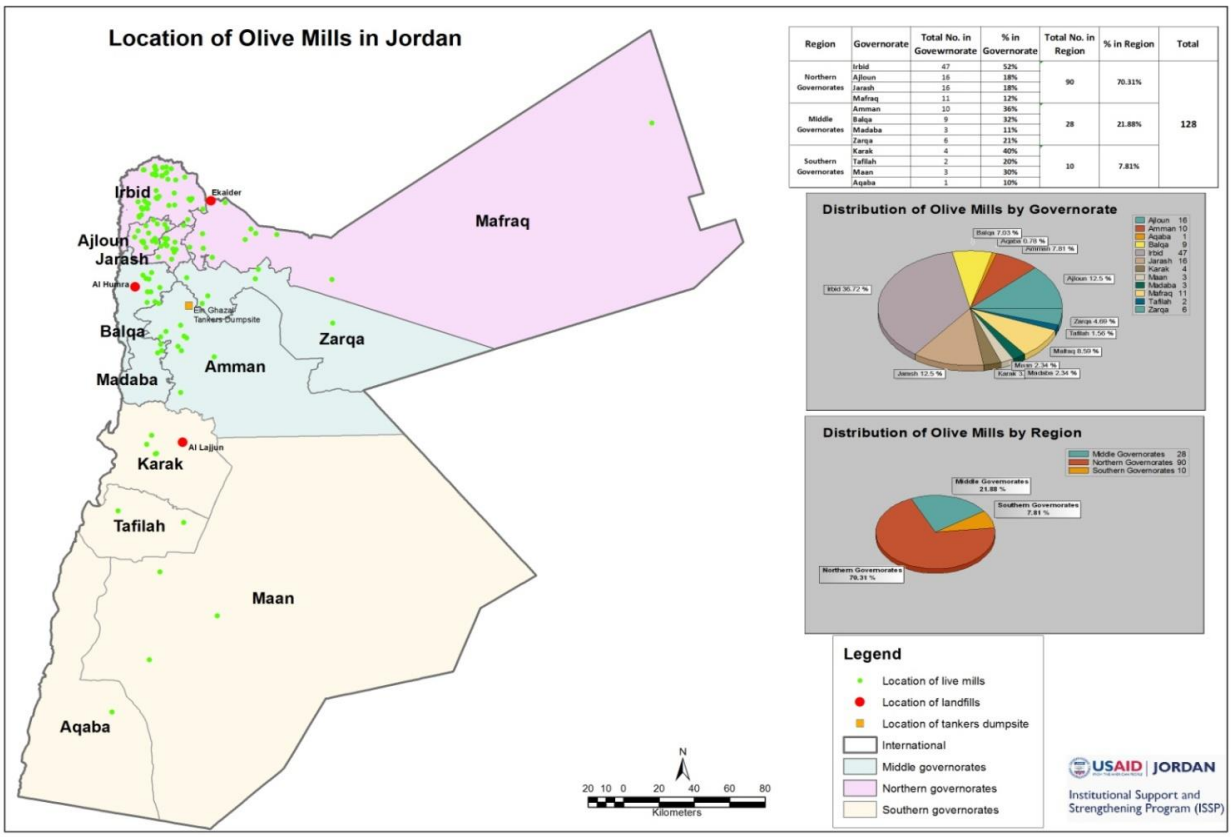
Jordan has more than 15 million olive trees that produce more than 130,000 tons of olives. 85% of the olives produce is sent by farmers to the olive mills for olive oil production. Two Types of waste are generated from the process of olive oil extraction; one is a solid residue called Pomace (or Jift as

locally named) and a liquid waste which is Olive Mill Wastewater (OMWW) or Zibar[1] as named locally in Jordan and as will be referred to in this report.

There are 128 olive mills in the whole of Jordan equipped with a 253 total number of production lines and a total production capacity of 364.4 Tons/hour, 70% of these mills are located in the northern region while 22% and 8% are located in the middle and southern regions respectively (Figure 1). These olive mills operate during the olives season that spans between mid October and mid January (around 75 days). The maximum Zibar generation is during the month of December due to the increase in olive oil production.

There are different oil extraction techniques that mainly affect the quality of the olive oil produced; in particular on the physico- chemical and organoleptic characteristics of the olive oil. Recent statistics of the 2012-2013 Ministry of Agriculture (MOA) showed that 7% of the 128 mills in Jordan use traditional pressing techniques, whereas the rest uses modern pressing techniques (3-phase and 2-phase mills). It is reported that the 3-phase mill produces larger amounts of Zibar (i.e. for each 1 kg of olives, 0.6 liters of Zibar are produced by the traditional method, 1.5 liters by the 3-phase, and 0.1-0.15 by the 2-phase).

[1] Even though the Ministry of Agriculture provides separate quantities for the Zibar (amount of vegetation water coming out of processed olives) and for the Olive Mill Wastewater (of vegetation water coming out of processed olives in addition to the water consumed for the different oil extraction processes), however, since they are both treated the same and both waters are collected in the same tanks, then in this report, Zibar refers to the summation of both waters (the amount of vegetation water coming out of processed olives in addition to the water consumed for the different oil extraction processes).



Region	Governorate	Total No. in Govewmorate	% in Governorate	Total No. in Region	% in Region	Total
Northern Governorates	Irbid	47	52%	90	70.31%	128
	Ajloun	16	18%			
	Jarash	16	18%			
	Mafraq	11	12%			
Middle Governorates	Amman	10	36%	28	21.88%	
	Balqa	9	32%			
	Madaba	3	11%			
	Zarqa	6	21%			
Southern Governorates	Karak	4	40%	10	7.81%	
	Tafilah	2	20%			
	Maan	3	30%			
	Aqaba	1	10%			

Figure 1: Spatial distribution of olive mills in Jordan

The total amount of Zibar produced in Jordan in 2012 is 212,418 m3 that resulted from processing of 115,282 tons of olives. The amounts of Zibar generated from each governorate are shown in Figure 2 below:

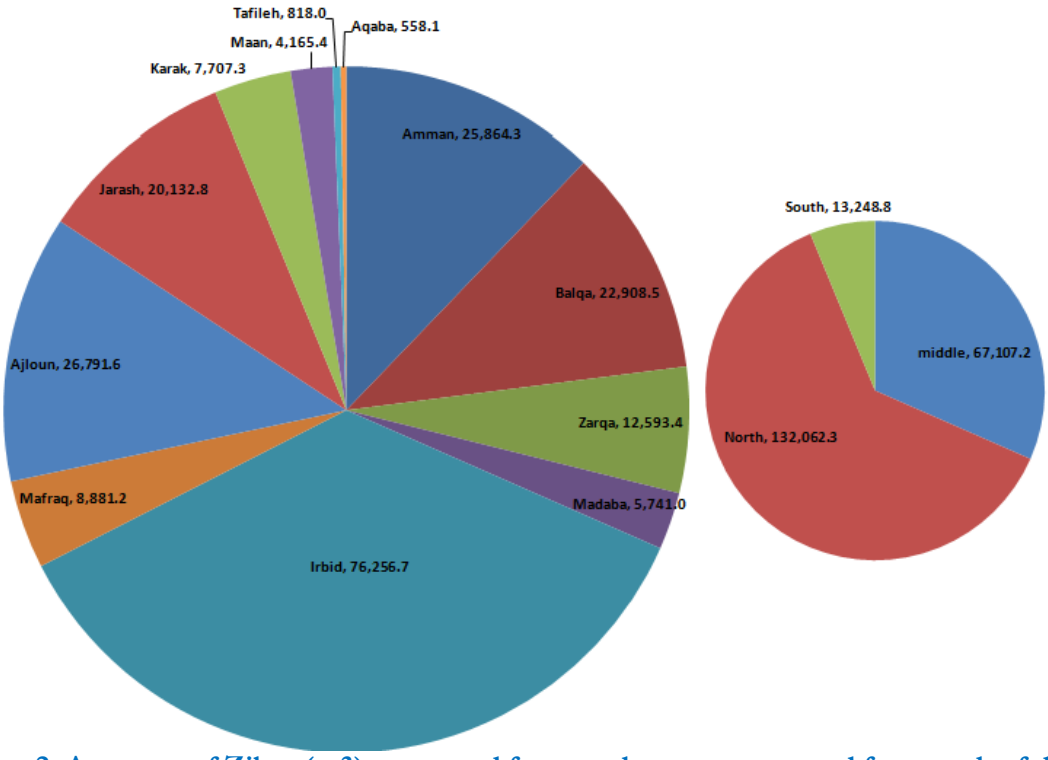


Figure 2: Amounts of Zibar (m3) generated from each governorate and from each of three regions in Jordan (MOA, 2012)

1.2.2. CHARACTERISTICS OF ZIBAR AND ITS IMPACT

Zibar has a black or reddish black due to the presence of phenolic compounds (10,650 mg/l), strong offensive smell; high percentage of fat, oil, and grease –FOG (10,650 mg/l); and extremely high organic load (BOD values of 45,000 mg/l and COD of 92,000 mg/l) which makes it 400 times higher than the organic load of domestic wastewater). Additionally, Zibar is acidic, and contains high concentration of total suspended solids (TSS), total dissolved solids (TDS), phenols, and other organic matter. If spread on soil and in disposed in wadis, Zibar includes many chemicals that can cause serious environmental problems and reduce the soil fertility.

Based on the 'Integrated Waste Management for Olive Oil Pressing Industries in Lebanon, Syria, and Jordan' study of 2007, it was reported that the minimum annual cost of environmental degradation due to the improper management of the waste produced by the industry was around 2 million in Jordan while it was reported to be 24 million in Lebanon.

It is prohibited to dispose of Zibar in the sewer because it is highly corrosive and it has high suspended solids and may cause clogging of the wastewater network in the vicinity of the olive mills. Also, should part of the illegally dumped Zibar reach the municipal Wastewater Treatment Plants (WWTP), it will negatively impact the regional environment due to its toxicity to microorganisms in domestic wastewater treatment plants, its strong and unpleasant odor after anaerobic digestion, and also due to its potential threat to surface and groundwater sources. Most of the problems associated with Zibar can be attributed to the phenolic fraction where more than 30 different phenolic compounds have been identified in Zibar and the types and concentrations of phenolics reported in Zibar vary tremendously. It has been reported that phenolic compounds are responsible for several biological effects, including antibiosis and phytotoxicity, and the antimicrobial activity is principally due to phenolic compounds such as tyrosol and hydrotyrosol. Due to the presence of high load of toxic organic compounds, the improper discharge of Zibar causes the disruption of biological activities in domestic wastewater ponds. Generally, Zibar contains high concentrations of phenolic compounds which inhibit microbial activity and thus makes biological treatment or microbial fermentation difficult. This creates a strong and unpleasant odor due to aerobic digestion in open air systems, and poses a threat to surface and groundwater.

1.2.3. MANAGEMENT PRACTICES OF ZIBAR IN JORDAN

There are no proper facilities for treatment or disposal of Zibar in Jordan. Three dumpsites have been designated by the Ministry of Environment (MoEnv); Ekaider in the north of Jordan, Al Humra in the middle, and Al Lajjun in the south (Figure 1). None of these dumpsites has lined evaporation ponds and subsequently none is equipped with proper mitigation measures to prevent the environmental impacts of Zibar disposal.

Based on discussions with various olive mills located in each of three regions, the following points regarding compliance were raised:

1. Ekaider dumpsite in the north region: even though the dumpsite located in Mafraq governorate was originally designated for municipal solid waste. But it also received industrial wastewater, sludge from Water Authority of Jordan Wastewater Treatment Plants, and Zibar. Generally, the yearly operational permit of the mills in the northern governorates is conditional compliance and hence most of the olive mills in the north of Jordan are committed to sending their generated amounts of Zibar to Ekiader. During the season (October-April) Zibar is disposed in the dumpsite in dedicated Zibar ponds for a yearly tariff of 330 JD per production line paid to the Irbid Joint Services Council. Any Zibar disposed outside the season (May-September) is charged at a tariff of 0.75 JD per m3 similar to other industrial wastewater. The environmental and health situation in the dumpsite does not meet any of the national or international standards and Ekaider has long been assigned as a hot spot location. Many studies have been prepared for rehabilitation of the landfill but nothing is implemented so far.
2. Al Humra dumpsite in the middle region: this dumpsite located in Balqa governorate is designated to receive solid waste but has been closed many times due to environmental issues. In 2012, the Ministry of Environment designated the dumpsite to receive Zibar after establishment of a Zibar evaporation pond in the dumpsite. However, the pond was overfilled after a one season use and since it could not receive further amounts of Zibar, the responsible authorities (municipality, Joint services council, and local governor) decided to prevent Zibar from being disposed in the dumpsite. This makes it expensive for olive mills to send their generated Zibar to Ekaider in the north due to the very long distance, and so this results in illegal disposal on Zibar in Wadis, sewer networks, or mixed with municipal wastewater and dumped in the Ein Ghazal "tankers dumping yard" (Figure 1) in Amman.
3. Al Lajjun dumpsite in the southern region: the dumpsite located in karak governorate is designated for liquid waste and even though it is unlined it is considered to be suitable for Zibar. According to discussions with olive mills in the south of Jordan, it was found that due to distance reasons the four (4) mills located in Karak comply with the requirements and dispose their Zibar in Lajjun and they pay an amount of 200 JDs per production line per season. However, the remaining six (6) mills do not. Even though it is not explicitly stated, it is assumed that these mills dispose randomly of their generated Zibar.

Based on the discussions with various olive mill owners in Jordan, it was found that the same licensing and compliance linkages implemented in the northern region are not implemented in the middle and the southern governorates which reduce the commitment by olive mill owners to compliance in terms of proper Zibar management and disposal practices.

In conclusion, many of the olive mills send their Zibar to the designated dumpsite, if available and if that does not implicate additional transportation cost that the mill cannot afford (e.g. a mill in Irbid pays around 16,000 JD per season for transportation cost to Ekaider, a mill in Salt – Balqa would be asked triple that amount to transport to Ekaider which is very costly and so the mill does not). The rest of the olive mills and/or the transportation tankers illegally dispose their Zibar in wadis, sewers, or the Ein Ghazal "tankers dumping yard" in Amman.

1.2.4. LEGAL AND ACTUAL MANAGEMENT PRACTICES OF ZIBAR

The operations and activities that should be implemented by the olive mills/transportation tankers in Jordan in accordance to the relevant legislations to ensure compliance vs. the actual practices that are potentially implemented on the grounds are summarized in Table 1 below:

Table 1: Legal Operations and Activities in Relation to Zibar Management

Phase	Responsibility	Legal Operations and Activities - compliance	Actual Operations and Activities
Phase 1 - The Olive Mill	The olive mill owner	1. Planning, design, and licensing (construction and operation license) of the olive mill 2. Emptying and cleaning the Zibar storage tanks and transferring the water to a tanker for transportation before the start of the olives season in order to have the tanks ready to receive the newly generated Zibar 3. Setting up an agreement with the nearest designated landfill for final disposal of Zibar. 4. Renewal of operation license (license valid from 1 Oct till 30 September) 5. Opening the mill during the olives season as per the timeframe set for the season (the timeframe is set for each year according to the season and production, e.g. 2013 season has been set to start on the 15th of Oct by MOA) 6. Commencement of the olives season and the oil extraction processes 7. Generation of Zibar and its storage in the storage tanks 8. Coordination with a tanker to empty the tank at a certain rate (e.g. once or twice each day depending on the production capacity and actual oil production in the mill) and ensure that it is being disposed in the designated landfill 9. Emptying and cleaning of the Zibar storage tanks	1. Operation of the olive mill without a license. OR Changing, modifying, or expanding the operation lines in the mill without a license. 2. Installing and using improper Zibar storage tanks (e.g. permeable from the bottom or/& sides, uncovered, no opening in the cover to allow for aeration or cleaning, insufficient capacity to mirror the production capacity of the mill…etc). 3. Emptying the Zibar storage tanks and random disposal on the grounds of the olive mill or outside its boundaries. 4. Operating the mill without having an agreement with a designated landfill for disposal of Zibar or having an agreement for licensing purposes only and not for actual implementation. 5. Random disposal of Zibar on the grounds of the olive mill or outside its boundaries, OR overfilling of the Zibar storage tanks due to insufficient capacity. 6. Coordination with a tanker to empty the tank at a certain

Phase	Responsibility	Legal Operations and Activities - compliance	Actual Operations and Activities
			rate (e.g. once or twice each day depending on the production capacity and actual oil production in the mill) and agree (explicitly or implicitly) on disposal of the Zibar in the wadis or in the sewer network without any treatment.
Phase 2 - Transportation by Tankers	The transportation tanker and potentially the olive mill owner	1. Collecting the Zibar from the olive mill 2. Transporting the Zibar to the nearest designated treatment plant or landfill	1. Collecting the Zibar from the olive mill 2. Transporting the Zibar and disposing it in wadis or in the sewer network without any treatment.
Phase 3 - Disposal in the Designated Landfill	The transportation tanker and potentially the olive mill owner	1. Disposal of Zibar in the designated treatment plant or landfill	1. Disposal of Zibar in a non-designated landfill 2. Illegal disposal and not reaching the designated landfill in the first place

1.2.5. REGULATORY AND INSTITUTIONAL SETUP

In terms of regulatory and institutional setup, there are clear gaps related to policy, legal, and institutional framework for Zibar management in Jordan, which has resulted in environmental mismanagement and pollution. This is exacerbated by the lack of a unified policy and legislations that regulates Zibar management amongst olive oil producing countries. In Jordan, due to its characteristics, Zibar is considered as an industrial wastewater and is regulated as such.

Concurrently, there is no clear mandate given to any of the different authorities that instates them liable in relation to Zibar except for the Ministry of Agriculture (MOA) who is solely responsible for licensing of olive mills and ensuring proper storage of Zibar within the grounds of the mill itself but MOA's mandate ceases at the boundaries of the olive mills.

The MoEnv, who is the responsible entity for regulating and monitoring industrial wastewater management practices, assumes the role of a supervision entity to ensure environmental protection only and does not have a mandate for implementation. They can outline a Zibar management policy, prepare standards and criteria in relation to Zibar management, establish the basis for management of Zibar from generation to final disposal and treatment, and oversee their implementation; but they do not. On the grounds, the MoEnv confesses to the many challenges faced in relation to illegal dumping of Zibar and the absence of treatment facilities but they currently do not have enough capacity to implement oversight and monitoring to ensure compliance and accordingly limit their inspection functions to responding to complaints (not necessarily in relation to Zibar per say).

The Ministry of Water and Irrigation (MWI) and the Water Authority of Jordan (WAJ) on the other hand have the following responsibilities in relation to wastewater: MWI's role is mainly planning for the water and wastewater sector, and WAJ as the implementation arm of MWI assumes all the responsibilities related to water and wastewater structures; their design, construction, operation, maintenance and administration. Accordingly, WAJ should study and plan for solutions for Zibar treatment and construct the preferred Zibar treatment scheme; but they do not. On the ground, the MWI/WAJ staff when asked, claim that their responsibility is only implementation of wastewater projects (network, pumps, WWTP …etc) for municipal wastewater only and not any other type of wastewater (Industrial, Zibar…etc).

Additionally, other monitoring takes place by the same or other entities such as Ministry of Health (MOH) monitors to ensure protection of public health; MOH and WAJ monitors to ensure protection of water resources, MOH and Ministry of Municipal Affairs (MOMA) monitors to ensure prevention of nuisances, and WAJ monitors to ensure protection of public wastewater networks and municipal wastewater treatment plants.

1.2.6. MAIN LEGAL AND INSTITUTIONAL ISSUES

- MOA and MoEnv officials report that they struggle to find an environmentally friendly and economically feasible disposal method for Zibar. Officials report that the Government does not have the funds to establish a central treatment plant or a common disposal facility for Zibar in Jordan.
- Insufficient legislations as well as weak enforcement multiplied with the incapability of mills to support an engineered solution and the lack a well-practiced cost efficient end solution, together, create the enabling environment for illegal dumping of Zibar to wadis and sewers as currently practiced in Jordan.
- On the ground, MoEnv does not have the logistical and financial capacity to conduct regular inspections on discharge of neither industrial wastewater nor Zibar in Jordan and thus only conducts "upon-complaint" inspections. Hence, MoEnv are liable by law to enforce environmental protection but on the ground, this is not implemented in full. The Environmental Rangers support the MoEnv in their duties but, based on discussions, it seems that there is no proper communication and updates between the Rangers and the MoEnv.
- Furthermore, MoH does not conduct any inspections within the water sector unless for water assigned for drinking purposes therefore, MoH delegates the responsibility of inspections on industrial wastewater onto the entities it considers in charge; those being MoEnv, MWI, WAJ and MOMA (and GAM).
- The Ministry of Water and Irrigation (MWI) and the Water Authority of Jordan (WAJ) on the other hand have the following responsibilities in relation to wastewater: MWI's role is mainly planning for the water and wastewater sector, and WAJ as the implementation arm of MWI assumes all the responsibilities related to water and wastewater structures; their design, construction, operation, maintenance and administration. On the ground, the MWI/WAJ staff when asked, claim that their responsibility is only implementation of wastewater projects (network, pumps, WWTP …etc) for municipal wastewater only and not any other type of wastewater (Industrial, Zibar…etc).

- Since no legislations govern Zibar management - and this is aggravated by the lack of clear legislations that address the issue of inspections carried out on tankers transporting Zibar from the point of generation to the allocated industrial wastewater treatment plant as well as the weak inspection and enforcement, most the tankers transporting Zibar in the middle and south of Jordan end up discharging their loads into the nearest valley or into the Ein Ghazal "tankers dumping yard" (Figure 1) which is designated for discharge of municipal wastewater only. Tracking of industrial wastewater tankers is assumed to be the responsibility of the MoEnv but that is not actually implemented by MoEnv on the ground.
- Generally, olive mills in the north of Jordan do send their Zibar to Ekaider. However, Ekaider is in a really bad shape and is an actual environmental disaster. Olive mill owners agree that if a proper final disposal for Zibar were to be established by the responsible government entity, then they will have to comply. But they do not see the current situation in Ekaider as a convincing motive for them to comply. Most of the mills in the north comply by sending their Zibar to Ekaider only because they need to in order to get the operation license.
- Apart from lacking the financial resources, many mill owners are unaware of the environmental damage they are causing. There is a lack of education as to why and how Zibar needs to be dealt with, so in general, mill owners release the waste water not realizing it will harm their land as well as the wider environment. When asked, olive mill owners claim that tankers come at night and dump their wastewater outside towns damaging crops and causing a bad smell.

1.3. Technologies and Methods of Zibar Treatment

The difficulties of Zibar treatment are mainly related to high organic loading, seasonal operation/generation, high territorial scattering, and the presence of organic compounds which are hard to biodegrade such as long-chain fatty acids and phenolic compounds. The problem of Zibar management and treatment has undergone extensive study during many years in the different olive oil producing countries and many possible solutions have been considered. However, due to lack of financial means as well as lack of knowledge and know-how, it may not be financially and technically feasible to implement such treatment options in small and medium olive mills, therefore, a downstream centralized treatment plant for Zibar is more suitable than upstream treatment options. Table 2 below lists the potential Zibar treatment technologies most appropriate for the purpose of this study.

Table 2: Technologies and Methods of Zibar Treatment

Treatment Option	Description	+ve	-ve
Evaporation Ponds (Lagooning)	• Based on lagooning in evaporation ponds after neutralization with lime. • Treatment usually includes the following elements: o Contact reactor with addition of lime o transport system o evaporation basin	• The most common Simple Low fixed investment and operational cost treatment option • Option is not high technology and requires less operation and maintenance works and doesn't require highly experienced staff to treat the Zibar. • The olive mill owners already showed unwillingness to pay for additional Zibar dumping fees, so, the lowest cost treatment method would be preferable. • The only by-product from this option is dry sludge that can be disposed of in the closest solid waste landfill.	• Needs large areas (1 m2 per 2.5 m3 of waste water) • Lagoons have to be located at least 2km away from domestic areas • Threat of leakage of the wastewater through the soil and into the groundwater • Produced odors in the surrounding area.
Classification by Gravity	• Comprises a gravity settling concrete basin divided into three sections with concrete partitions, an open soil trench, a concrete platform for the post handling of the settled sludge and a soil-plant filter the disposal of the excess supernatant from the storage lagoon. Resulting waste fractions are handled separately.	• Simple and efficient.	• Fixed investment and operational cost is higher than for the Lagooning option
Anaerobic Digestion (AD)	• The completely mixed anaerobic digester is the basic anaerobic treatment system with a hydraulic retention time and solids retention time in the range of 15-40 days in order to provide sufficient retention time for both operation and process stability.	• Methane production • 70% reduction in organic pollutants	• Effluents discolored and polluted, cannot be released into environment. Sludge continues to be toxic and needs further treatment • Zibar characteristics are toxic for the methanogens—the vital bacteria types for the anaerobic treatment. • Due to the seasonal olive oil production; Zibar must be co-treated with other wastewaters (dairy waste, etc.). • High fixed and operation cost, and complicated system.
Up-flow anaerobic	• Influent upward flow in the UASB reactor travels through the sludge blanket and passes out around the	• Good settleability, low retention times, elimination of the packing material cost, high biomass concentrations	• If the wastewater has high solid content, this prevents the dense granular sludge development. Design OLR

Treatment Option	Description	+ve	-ve
sludge blanket reactor[2]	edges of a funnel, increasing retention time and efficiency of solids separation from outward flowing wastewater. Granules which naturally form after several weeks of the reactor operation consist primarily of a dense mixed population of bacteria responsible for the overall methane fermentation of substrates.	(30000-80000 mg/L), excellent solids/liquid separation and operation at very high loading rates can be achieved by UASB systems.	is typically in the range of 4 to 15 kg COD/m3.day. • It needs post treatment, the need for mixing with other types of industrial wastewater, and long start-up stage.
Co-Composting of Zibar with Olive Stone Waste Residues	• Olive stone waste residues are mixed continuously with Zibar in a vessel-composting reactor under controlled temperature and moisture levels, necessitating feeding the Zibar at a certain rate to follow the need for moisture content and in the same time, feeding the olive stone waste residues at a certain rate to follow the need for carbon content. Olive stone waste residues and destroyed and turned it into solid waste that after a 1-2 months maturity period can be transformed into a soil conditioner.	• This method is an integrated method for Zibar management; the end products comply with national legislations, and produce a marketable by-product.	• Low rate of composting due to phenolic toxicities of the substrate. Depending on the type of bioreactor, Zibar must be stored for less or long time creating the same environmental problems of that of evaporation ponds, the pomace (Jift) could not replace the olive stone waste residues because of its high toxicity, else the final product could not be characterized as a biological fertilizer. The method is complex.

[2] Recommendations by RSS pilot UASB: The construction of central treatment plants in the different areas (e.g. 9 central treatment plants), the effluent of these plants is to be discharged in the existing domestic WWTPs for further treatment, and the treated Zibar effluent will be reused in irrigation.

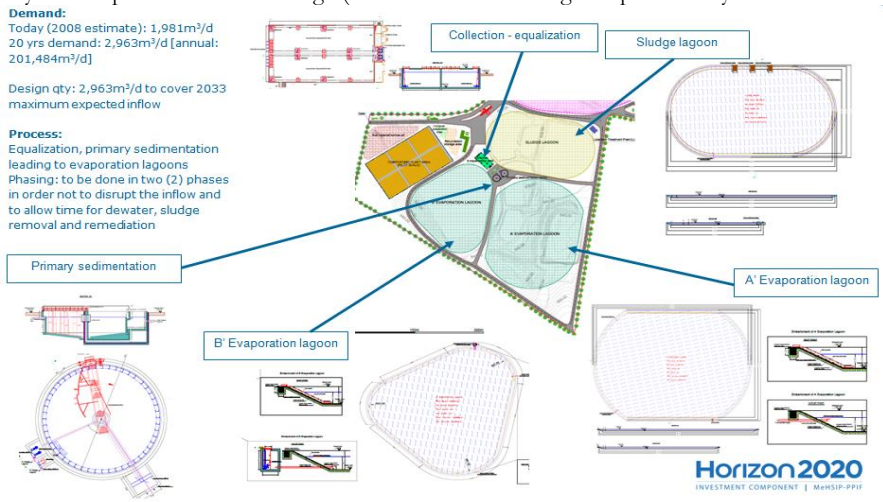
1.4. RECOMMENDATIONS FOR JORDAN

The solution to the Zibar problems needs the collaboration of all entities involved and the harmonizing of their efforts. Holistic planning is needed to implement a master plan for Zibar management and this will be done by linking upstream with downstream operations through planning, research, regulatory, institutional, financial, and technical means. Table 3 below presents the potential improvement recommendations to be applied upstream and downstream of the management chain. In conclusion, the solution of the Zibar management issues in Jordan requires a trilogy of suitable legislations, proper inspection and enforcement, and last but not least, proper disposal and treatment facilities spatially distributed within the three regions of the country. An integration of these solutions, with political support, will help solve issues with Zibar management in Jordan.

Table 3: Improvement Recommendations for Zibar management in Jordan

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
Upstream	**Policy and Institutional**	• Specify responsibilities and interrelated mandates of different entities and the entity to lead and plan Zibar management • Assigning MoEnv to have full authority over Zibar management in Jordan (the core entity responsible for industrial wastewater) • MoEnv should in collaboration with other entities introduce a new Zibar management policy, action plan, and proper legislations • MoEnv should formulate an inter-organisational communication scheme and protocol to facilitate communication between agencies • Adopt/customize regional/international best practices, policies, and legislations in olive oil producing countries • MoEnv should prepare the necessary standards, instructions, guidelines in relation to Zibar management, characteristics, transportation, handling, treatment, disposal…etc. • Introduce necessary measures for institutional strengthening and internal capacity building to ensure sustainability • MoEnv should formulate various documents that will help guide the operations of Zibar, and enable effective regulation, monitoring, development, management, and operation. • MoEnv in collaboration with the Environmental Rangers should undertake sufficient monitoring and inspection to ensure enforcement and compliance • MoEnv should work together with MWI/WAJ or/& MOMA to plan establishing a proper final disposal/treatment scheme for Zibar and together with these potential implementation entities find suitable funding mechanisms to ensure sustainability. • MoEnv should work on raising awareness of olive mill owners & tankers regarding the negative environmental impacts of illegal Zibar disposal. • MOA to complete its successful inspection and licensing process and learn by experience ways to strengthen the process. They should ensure proper maintenance of Zibar tanks before start of the season in the most efficient ways possible to ensure proper operation during the season. • MoEnv, MOA, in collaboration with other entities should develop a manifest system that tracks Zibar from generation in the olive mill to final disposal in the treatment plant. The tracking system should ensure no discrepancy in the amounts of Zibar throughout the chain. Compliance is measured through different indicators including inspection and the manifest. Operational Licensing should be granted conditional the manifest records throughout the season. Noncompliant mills and transportation tankers should be penalized • MoEnv and MOA can help promote best practices in the olive mills by applying proper regulations, using economic instruments, providing support measures, obtaining external assistance, channeling research to help guide the management processes within olive mills, raising their awareness, implementing finance mechanisms (revolving funds, microfinance…etc).	• Capacity buildings for MoEnv and Environmental Rangers and one representative from each line ministries: 150,000 USD/training session (10 trainees in each governorate for one week in Jordan) • Technical Assistance to MoEnv to formulate policy, action plan, guiding manuals, instructions, guidelines…etc: 110,000 USD for an international consultant working full time for 3 months • Logistical support to MoEnv to undertake inspection during the season: 250,000 USD for one car purchase for each governorate and 26,000 USD operational costs (Fuel and maintenance) for these cars per season • Support to MOA for inspection in olive mills: 7000 USD/season • Incentives to MoEnv/Rangers inspectors: 30,000 USD/season (3 inspectors in each governorate)
Downstream	**Institutional**	• WAJ &/or MOMA in cooperation with MoEnv shall collaborate to select the most suitable option for	• Capacity building of Zibar

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
		Zibar treatment, select suitable locations for the Zibar treatment plant for each of the three regions (criteria for site selection: distance from community, availability of land, closeness to all mills, environmental factors such as water resources and biodiversity…etc. Location could be within an existing WWTP or within an existing landfill), and to discuss the following: examine ways for funding, possibility for public private partnerships, best management scheme of the treatment plant, capacity building of staff, formulating the operational manual of the plant, …etc). • MoEnv to undertake regular monitoring and check of the treatment efficiency of the Zibar, the quality of the effluent, and protection of environment. They should also review the monthly reports prepared by WAJ/MOMA for the Zibar treatment plant and ensure its compliance • Capacity building of Zibar treatment plant staff (WAJ &/or MOMA) • Zibar treatment plants developers to apply for Environmental permitting (location permit, EIA) • Capacity and facilities to implement the environmental monitoring program	treatment plant staff (WAJ &/or MOMA): 25,000 USD/year • Technical assistance to WAJ &/or MOMA: 800,000 USD for design, feasibility study, institutional study, procurement, and tendering • MoEnv regular monitoring and monthly follow-up: 7000 USD/year • Location permit: 600 USD for three locations • EIA: 100,000 USD for three locations • environmental monitoring program: 30,000 USD/year
	Technology	• WAJ &/or MOMA shall implement the Zibar treatment plant (depends on the selected location; MOMA if in landfill land and WAJ if in WWTP land. • Zibar generation is only seasonal (85 days between mid October till mid of January) and hence, the design flow-rate should be based on the flow during peak season (1,750 m3/day for north, 550 m3/day for middle, and 200 m3/day for south). The forecasting of Zibar generation should be studied in further details before finalizing the treatment plant designs. • Evaporation ponds (lagooning) are the most suitable and feasible technology for Zibar treatment. It has been proposed by the study funded by the European and Investment Bank (EIB) as part of the Horizon 2020 Program; 'Integrated Solid Waste Management in Al-Ekaider – Jordan' in 2012, a technical description and conceptual design has been provided in the October 2012 Feasibility Study Integrated Solid Waste Management in Al-Ekaider' submitted to the Ministry of Municipal Affairs and to the WAJ representative member of the committee for review and comments. It is being also included in the proposal being prepared by the MoEnv for Zibar treatment to be submitted to the prime ministry. • This technology is a combination of evaporation ponds with solids removal in sedimentation tanks and sludge stabilization by addition of lime. Lime addition in Zibar sludge does not cause any problems to the sludge's composting process if appropriate dosing is done. • The phases of the plant are the following: Tanker receiving station; Collection / equalization tank; Constant flow pumping station; Chemical dosing with lime; Sedimentation tanks; Zibar sludge removal; Oil – grease removal; Oil separation with centrifugal system; Distribution chamber; Two stage lined evaporation lagoons; Sludge dewatering lagoon; Composting of dewatered Zibar sludge; and Recirculation of water in the compost unit. • The minimum area proposed for the evaporation lagoons for the northern governorates was proposed by Horizon 2020 to be 58,055 m2. However, this area should be revisited since the calculations were based on	• Based on the findings of the feasibility study as part of the Horizon 2020 Program, the following tariff implications are concluded for the ZTP in the north region (70% or the Zibar quantities): • Investment cost (CAPEX) was estimated to be 6,948,285 USD. • Yearly operational cost (OPEX) for ZTP (chemical and materials, and the personnel cost) is estimated to be around 338,000 USD/year

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
		68 days season and not 85 and on 1381 m3/day of Zibar and not 1,750 m3/day. According to the calculations all Zibar will have evaporated before the new production period starts. Some suspended solids remains in the Zibar from the sedimentation tanks. These solids will sediment at the bottom of evaporation lagoons. Every 5-6 years, sludge will need to be removed from the evaporation lagoons (manually, due to the geosynthetic nature of the underlying membrane) and sent to the sludge lagoon. • Layout and plan for the ZTP design (further detailed drawings are provided by the Horizon 2020 study):  	
	Tariff and cost recovery	• MoEnv should cooperate with WAJ &/or MOMA to study the existing tariff setup for Zibar disposal and prepare directional policies for cost recovery that reduce cost of environmental management, but ensure compliance and environmental protection. The tariff structure will depend on the funding scheme for the new Zibar treatment plant (direct Govt funding, private investment, partial Govt investment …etc). As it stands, if the Zibar treatment plant were to be implemented, there is only one source of revenue and that is the Zibar disposal fees. There is no link with actual quantities of Zibar disposed in landfill and it varies between the north and the south regions. Tariffs should be set based on quantity rather that fee per production line which would be more equitable to mills, as they would pay for what they produce, and avoid the possibility of mills cross-subsidizing others due to differences in production line output. • Based on Horizon 2020 study for the north region, the amount of funding required for developing and operating the project over the 13 years of the project period stands at € 6.58 million (8.9 million USD). • Horizon 2020 found that: Net Present Value and Internal Rate of Return estimations were negative and pointed towards the rejection of the project from a financial point of view, ZTP not financially valuable investment, need to find alternatives to fund the deficit in Capex and Opex, ZTP will never be able to cover its OPEX at the existing tariff.	• Based on the above capex and opex costs vs. the current effective zibar fees, the Horizon 2020 concluded that the revenue growth rates are declining and that revenue growth ranges from 1.3% to 1.5%, which is considered a weak growth rate. • The Horizon 2020 feasibility study found that one of the possible options is to increase the tipping fee of the Zibar disposal to cover the plant cost. In the case of a full cost

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
		• Increase tipping fees from 330 JD/production line/season to 1320 JD/production line/season if no funds available to cover CAPEX • Increase tipping fees from 330 JD/production line/season to 409 JOD/production line/season with Govt funding for CAPEX • It is suggested that the government could contribute to the ZTP development CAPEX and increase gradually the tipping fee to cover the OPEX. If the government paid the full ZTP CAPEX cost, then the tariff to cover the OPEX would need to be increased to 409 JOD/production line.	coverage (CAPEX and OPEX), the fee has to be increased by around 250% to 300% by year 13 in order to achieve a viable financial investment (1.35 USD/m3 up from the current 0.31 USD/m3). CAPEX should be covered by funds allocated by the responsible authorities.

2. INTRODUCTION

A wastewater master plan was requested by the minister of MWI in the meeting with ISSP on June, 30th 2013. H.E requested a simple master plan that can help MWI to determine investment priorities in wastewater services in Jordan. The master plan would then be used as a tool to help WAJ in their decision making process for capital investment in as WAJ currently has no long term plan for wastewater systems on the national level and priorities are not clearly identified. The wastewater streams to be studied as part of this master plan are: municipal wastewater, industrial wastewater, and olive mill wastewater (Zibar).

Due to the grave negative impacts of illegal dumping of Zibar, a holistic management approach obligates examining the issue of Zibar from the perspective of ensuring environmental protection, which places the Ministry of Environment on top of the entities responsible to regulate and oversee Zibar management. The Water Authority of Jordan is also involved in terms of implementation of the suitable Zibar treatment scheme.

Based on discussions with the MoEnv, it has been stated that they too are preparing a proposal in relation to Zibar treatment to be sent to the Prime Ministry. The MoEnv hopes that this proposal could help prioritise such investments to allocate funds from the Gulf funds.

This report presents background and understanding of the status quo in relation to Zibar management in Jordan, the legal and institutional setup, the potential treatment technologies for Zibar, and the recommended options for Jordan.

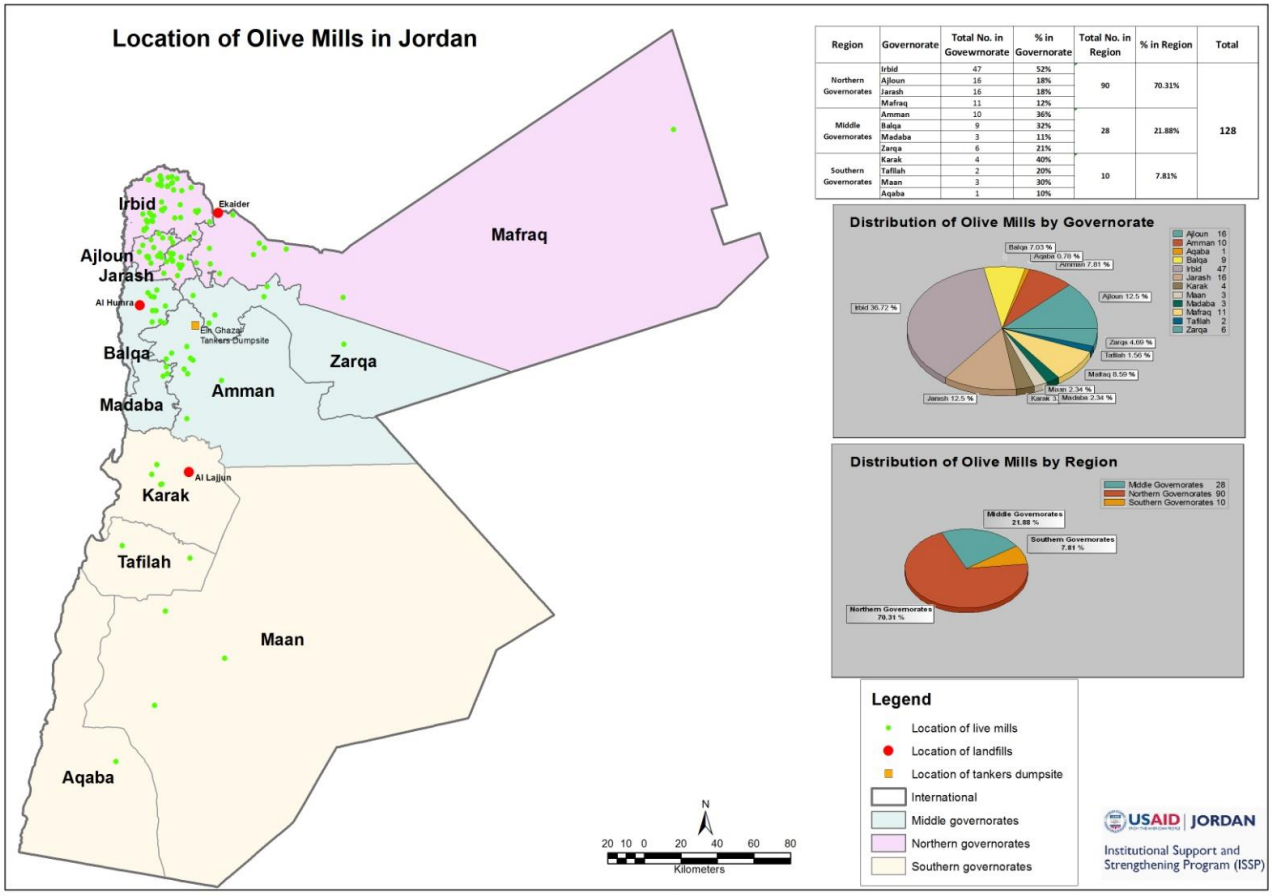
3. DIAGNOSIS OF EXISTING SITUATION

3.1. NUMBERS AND SPATIAL DISTRIBUTION OF OLIVE MILLS IN JORDAN

Jordan is amongst the countries that have defined olive oil production as a national priority. Notwithstanding that Jordan is a semi arid country with scarce water resources, according to the Ministry of Agriculture Statistics the area planted with olive trees increased from 285 Million m^2 in 1984 to 644.8 Million m^2 in 2002 with more than 15 million olive trees farmed which forms more than 73% of the total area planted with fruit trees. As per the FAOSTAT Jordan Country Profile of 2011, olives production ranked 6th place amongst the top ten commodities produced by the Country with a production quantity of 131,847 tons. The annual production of olives differs enormously from one year to the other and is known to be cyclical.

One third of the olives produced are used for table olive consumption, whereas the rest is used to produce olive oil. Recent statistics of the 2012-2013 Ministry of Agriculture (MOA) showed that Jordan has 128 mills, 7% of them uses traditional pressing techniques, whereas the rest uses modern pressing techniques (3- phase and 2- phase mills) equipped with full-automatic production lines and with a 253 total number of production lines and a total production capacity of 364.4 Tons/hour. The majority of the mills (70%) are located in North Jordan, followed by Middle Jordan (22%) and South Jordan (8%).

Figure 3 below shows the spatial distribution of these olive mills in Jordan:



Region	Governorate	Total No. in Govewrnorate	% in Governorate	Total No. in Region	% in Region	Total
Northern Governorates	Irbid	47	52%	90	70.31%	128
	Ajloun	16	18%			
	Jarash	16	18%			
	Mafraq	11	12%			
Middle Governorates	Amman	10	36%	28	21.88%	
	Balqa	9	32%			
	Madaba	3	11%			
	Zarqa	6	21%			
Southern Governorates	Karak	4	40%	10	7.81%	
	Tafilah	2	20%			
	Maan	3	30%			
	Aqaba	1	10%			

Figure 3: Spatial distribution of olive mills in Jordan

3.2. THE OLIVE MILL WASTEWATER (ZIBAR)

Zibar as named locally in Jordan is produced during the processing and crushing of olives in the mill. Basically it is liquid waste after the separation of oil. A solid residue called Pomace (Or Jift as named locally) is also produced.

Zibar can be described as a stable emulsion constituted by vegetation waters (water contained in olive fruit), water from the processing (added water required for washing the fruit, and for the centrifugation process), olive pulp, and oil. It is only produced during the season production months between mid October till end of January (i.e. 3.5 months).

3.3. Oil Extraction Processes and Mass Balance

During the processing of olive oil (generally mid October to January), olives are crushed and mixed with water. The oil is then separated out from the dirty water (Zibar) and solid residue (Jift).

There are different oil extraction techniques that mainly affect the quality of the olive oil produced; in particular on the physico- chemical and organoleptic characteristics of the olive oil. According to the 'Impact of olive oil pressing techniques on olive oil quality' study (2008), three systems are used to extract the oil from the olives and these are listed and briefly described below:

1. Traditional Method or the Pressing Technique: this is the old system used for oil extraction. This is not widely used and is being replaced by modern techniques that will be discussed in the list below. In Jordan, according to the MOA 2012-2013 statistics, only 7% of the olive mills in the whole of Jordan use the traditional method. Despite some operational requirements that require constant follow-up by the operator as well as other disadvantages, this technique has the advantage of producing the cold pressed olive oil which gives a better quality olive oil and consumes less amounts of energy.

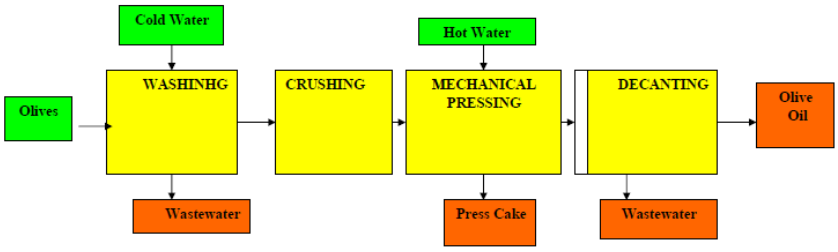


Figure 4: Schematic diagram for the traditional oil extraction technique or the pressing technique

2. 3-phase system: This technique extracts oil by horizontal centrifugation and produces three different outcomes: oil (93 % oil / 6 % water / 1 % solids), water (89 % water / 10 % solids / 1 % oil), and husk (53 % water / 3 % oil / 44 % solids). This system needs to have an inside layer of free water to facilitate the extraction of the oil. The oil resulting will contain less antioxidants. The oil that comes from a 3-phase system will have a more pungent, bitterer taste than the one from the presses but will be sweeter than the one from the 2 phases. The disadvantage of this system is the high produced quantities of Zibar.

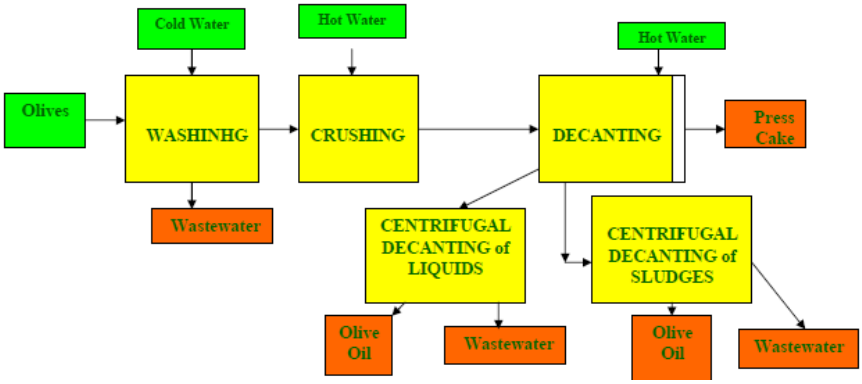


Figure 5: Schematic diagram for the 3-phase oil extraction technique

3. 2-phase system: This technique will extract by horizontal centrifugation and produces two different outcomes: oil (90 oil / 9 water / 1 solids), and husk (60 water / 4 oil /36 solids). This technique will yield less oil quantities and bitterer oil than the other extraction systems which is not preferred by consumers. The decanter in this system requires 20-25% less water than the 3-phase technique and thus results in much reduced Zibar.

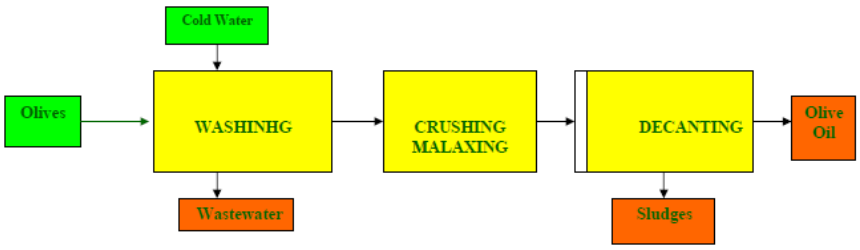


Figure 6: Schematic diagram for the 2-phase oil extraction technique

Table 4 below provides a comparison between the three oil extraction techniques and the input vs. output or material balance.

Table 4: Input Output Analysis of the Different Oil Extraction Processes in Jordan

Oil Extraction Method	Input	Amount	Output	Amount
Traditional	Olive	1000 Kg	oil	257.4 Kg
	washing water	100-200 liters	pomace	500 Kg
	energy	40-60 kWh	wastewater	666 liters
3-phase	Olive	1000 Kg	oil	256.4 Kg
	washing water	100-120 liters	pomace	581.16 Kg
	Hot water added	700-1000 liters	wastewater	1500 liters
	energy	90-117 kWh		
2-phase	Olive	1000 Kg	oil	257.4 Kg
	washing water	100-120 liters	pomace	735 Kg
	energy	90-117 kWh	wastewater	100-150 liters

It is found that consumers mostly prefer the oil extracted by the traditional method. However, in Jordan, most traditional mills have been replaced by modern ones. As described above and in Table 4,

the traditional method produces less amounts of Zibar but is being discontinued in Jordan. The modern oil extraction method could be 2-phased or 3-phased. Operators of the oil mill and also farmers do not prefer to use the 2-phase olive mill because it sacrifices part of its extraction capacity (i.e. less olive oil/kg olives processed), and the decanter coil expels the water together with the pomace, resulting in a more hazardous and wet pomace. Additionally, based on the quality of olive oil produced by both modern techniques, it could be assumed that the 3-phase is more desirable because it produces oil that is less bitter than that produced by the 2-phase. However, the downside of using the 3-phase mill is the larger amounts of Zibar produced (for each 1 kg of olives, 0.6 liters of Zibar are produced by the traditional method, 1.5 liters by the 3-phase, and 0.1-0.15 by the 2-phase).

According to the 2012-2013 list of MOA, only 7% of the mills in Jordan are traditional and the rest are modern. Based on further discussions with the MOA, 65% of the modern mills are 3-phased mills and this means that more Zibar is produced from these mills (as stated above, 1.5 liters for each 1 kg of olives). This Zibar need to be managed properly which is the main focus of this report.

3.4. Average Characteristics of Zibar

The color of Zibar produced as a result of the oil extraction processes is usually black or reddish black due to the presence of phenolic compounds.

The typical composition of Zibar includes water (83%), organic compounds (15%), and inorganic chemicals (about 2%). Based on 'An Evaluation of Biological Treatment Methods Used in Olive Mill Wastewaters' paper published by Yakup Cuci et.al, it is reported that the remaining waste from the olive oil extraction process still contains a small quantity (about 2-6%) of oil that cannot be extracted by further pressing, but only with chemical solvents. This is done in specialized chemical plants, not in the oil mills.

According to Yakup Cuci et.al, most of the problems associated with Zibar can be attributed to the phenolic fraction where more than 30 different phenolic compounds have been identified in Zibar and the types and concentrations of phenolics reported in Zibar vary tremendously. Yakup Cuci et.al reported that phenolic compounds are responsible for several biological effects, including antibiosis and phytotoxicity. The antimicrobial activity is principally due to phenolic compounds such as tyrosol and hydrotyrosol.

The Zibar has a strong offensive smell, high percentage of high organic COD concentration and oil. Another negative property of Zibar is the organic load in Zibar is considered one of the highest of all concentrated effluents (Generally Zibar is reported to have BOD values ranging between 12,000 and 63,000 mg/L and COD values between 80,000 and 200,000 mg/L) which makes it 400 times higher

than the organic load of domestic wastewater, and their oxidization time is more than 400 times longer than that of normal sewage water. As microorganisms present in the environment consume these materials, oxygen will be depleted from the water with adverse effects on the aquatic media.

Zibar is acidic, and contains high concentration of total suspended solids (TSS), total dissolved solids (TDS), phenols, and other organic matter. The organic content is characterized by high levels of chemical oxygen demand (COD), biochemical oxygen demand (BOD), and very high concentration of fat, oil, and grease (FOG)

The polythenols give the natural green and black coloring of the olives but in the same time are chemicals, when spread on the soil in large quantities cause serious environmental problems and reduce the soil fertility.

Figure 7: Zibar being produced during the operation processes in the olive mill

Common disposal practices for Zibar include direct discharge into soils or wadis and use of evaporation ponds or lagoons.

It is prohibited to dispose of Zibar in the sewer because it is highly corrosive and it has high suspended solids and may cause clogging of the wastewater network in the vicinity of the olive mills. Also, Zibar is not allowed to go into municipal wastewater treatment plants due to the toxicity to microorganisms, high organic COD concentration, and its resistance to biodegradation due to its high content of microbial-growth-inhibiting compounds (mainly phenolic compounds and tannins). It is also prohibited to dispose randomly in wadis and spread on soil due to the potential threat on surface and groundwater as well as the soil.

Due to the presence of high load of toxic organic compounds, the improper discharge of Zibar causes the disruption of biological activities in domestic wastewater ponds. Generally, Zibar contains

high concentrations of phenolic compounds which inhibit microbial activity and thus makes biological treatment or microbial fermentation difficult. This creates a strong and unpleasant odor due to aerobic digestion in open air systems, and poses a threat to surface and groundwater.

It is fundamental that the Zibar undergoes industrially feasible physico-chemical and biological treatment systems in order to reduce its environmental and health impacts.

According to the MOA, the characteristics of Zibar in Jordan are provided in Table 5 below. Additionally, the quality of Zibar is compared to applicable Jordanian legislations for the discharge and reuse of industrial wastewater. (Further details regarding the regulatory framework are provided in Section 0):

Table 5: Average characteristics of Zibar in Jordan

			Maximum Allowable Limits	
Parameter	Units	Avg. Characteristics of Zibar	WAJ Instructions for discharge of industrial and commercial wastewater to the sewer system for the year 1998	JS 202-2007 Industrial Reclaimed Wastewater Disposal to Wadis & Rivers
pH		4.8	5.5-9.5	6.0-9.0
EC	mmhos/cm	12	-	
TDS	mg/l	63,500	-	2000
TSS	mg/l	2,800	50	60
COD	mg/l	92,500	1500	150
BOD5	mg/l	45,500	-	60
FOG	mg/l	1,640	100	8
T-P	mg/l	530	-	
Total Phenolic Compounds	mg/l	10,650	10	0.002

3.5. Quantities of Produced Zibar

As included in Section 3.2, the Olives season spans a period of 3.5 months (i.e. 105 days, actual duration reported by various olive mill owners to be 75-85 days). According to the 2011 'Anaerobic Treatment of Olive Mills Waste: potentials for Watershed Protection in Jordan' study, mills work 24 hours a day only over a few days of the milling period; typically olive mills work 10-18 hours/day most of the milling period, and work 24 hours/day during around 40 days (20th November till the end of December).

In order to calculate the total Zibar production each day of the olives season, the following assumptions and estimations are used:

1. The average working hours during the olives season (85 days) is 10-18 working (hours/day). A 15 working hour period per day is assumed because mills do not work at full capacity throughout the season.
2. The average cubic meters water consumption per tons of processed olives is 0.65-0.85 (m^3/ton). A water consumption of 0.75 m^3/ton is assumed given the different water consumptions for the different oil extraction processes (Table 4).
3. Based on the 2011 'Anaerobic Treatment of Olive Mills Waste: potentials for Watershed Protection in Jordan' study, the amount of vegetation water coming out of processed olives is 40% of the quantity of processed olives (ton/hour).
4. Alternatively, according to discussions with different olive mill owners in Jordan, the average cubic meters of Zibar produced per ton of processed olives is 1.1-1.2 (m^3/ton).

Calculations based on Assumptions 1, 2, and 3 above:

1	2	3	4	5	6
Working Hours (Hours/day)	Production capacity (ton/hour)	Daily processed olives (Tons/day)	Water consumption (m3/day)	Amount of vegetation water coming out of processed olives is 40% of the quantity of processed olives (ton/hour).	Average cubic meters of Zibar produced per day (m3/day)
		Col 1 * Col 2	0.75 * Col 3	0.4 * Col 3	Col 4 + Col 5
15	364.4	5466	4099.5	2186.4	6285.9

Calculations based on Assumptions 1, and 4 above:

1	2	3	4	5
Production capacity	Working hours	Daily processed olives	Specific OMW production	Average cubic meters of Zibar produced per day (m3/day)
ton/hr	hrs	ton/day	m3/ton	m3/day
		Col 1 * Col 2		Col 3 * Col 4
364.4	15	5466	1.15	6285.9

However, based on discussions with different olive mills, it was reported that in the last 10-15 years, mills have only been operating at 40% of their production capacity due to the reduced

agricultural production of olives in Jordan and the increased number of olive mills in Jordan (Section 3.6.1).

So the average cubic meters of Zibar produced per day (m^3/day) can be assumed to be around 2500 m^3/day and accordingly the yearly production (in 100 days) is estimated to be around 212,500 m^3/season produced by 128 mills.

Northern governorates Zibar generation: 1,750 m^3/day (148,750 m^3/season)

Middle governorates Zibar generation 550 m^3/day (46,750 m^3/season)

Southern governorates 200 m3/day (17,000 m^3/season)

The figures above were calculated in the start of preparation of this document and were based on research performed for the purpose of this report. In comparison to the records received from the MOA in a subsequent date, it was found that the numbers calculated above are equivalent to the actual numbers received from MOA as shown in Table 6 below.

Table 6: Quantities of produced Zibar in Jordan (MOA, 2012)

Region	Governorate	olives used in production (ton)	olive oil produced (ton)	water used in oil extraction (m^3)	Jift (ton)	Zibar (m3)	OMWW (m3)	Total Zibar amounts (m^3)	oil %	Jift %	Zibar %
middle	**Amman**	13,913.0	2,208.0	12,191.5	4,848.6	6,836.4	19,027.9	25,864.3	16%	35%	49%
	Balqa	10,202.5	1,794.0	13,262.5	3,585.5	4,823.0	18,085.5	22,908.5	18%	35%	47%
	Zarqa	6,515.0	1,176.7	6,031.2	2,057.2	3,281.1	9,312.3	12,593.4	18%	32%	50%
	Madaba	2,908.7	474.8	2,909.4	1,018.1	1,415.8	4,325.2	5,741.0	16%	35%	49%
North	**Irbid**	39,504.9	7,188.1	39,349.5	13,863.1	18,453.6	57,803.1	**76,256.7**	18%	35%	47%
	Mafraq	4,881.3	743.2	4,093.2	1,744.1	2,394.0	6,487.2	8,881.2	15%	36%	49%
	Ajloun	19,008.0	4,412.7	10,703.0	6,551.0	8,044.3	18,747.3	26,791.6	23%	34%	42%
	Jarash	10,107.0	1,996.5	9,991.2	3,039.8	5,070.8	15,062.0	20,132.8	20%	30%	50%
South	**Karak**	5,588.9	1,097.9	2,514.9	1,894.8	2,596.2	5,111.1	7,707.3	20%	34%	46%
	Maan	1,992.5	346.4	2,316.0	721.4	924.7	3,240.7	4,165.4	17%	36%	46%
	Tafileh	379.3	71.2	472.0	135.1	173.0	645.0	818.0	19%	36%	46%
	Aqaba	280.5	38.3	280.5	103.4	138.8	419.3	558.1	14%	37%	49%
Total		115,281.6	21,547.8	104,114.9	39,562.1	54,151.7	158,266.6	**212,418.3**	18%	35%	48%

From the above table, the quantities of Zibar generated by each of northern, middle, and south governorates are as follows:

1. **Northern governorates Zibar generation: 1750 m^3/day or 148,693 m^3/season**
2. **Middle governorates Zibar generation: 550 m^3/day or 46,732 m^3/season**
3. **Southern governorates: 200 m^3/day or 16,993 m^3/season**

3.6. MANAGEMENT CHAIN OF ZIBAR IN JORDAN

The current Zibar management chain in Jordan typically includes three phases. The text under each phase is interrelated with the others and together, briefly tells the story of Zibar management from upstream to downstream.

3.6.1. PHASE 1 - THE OLIVE MILL

This phase starts with the olive oil extraction process in the olive mill and production of ZIBAR. Quantities generated depend on the number of production lines, the capacity (Tons/Hour) for each line, the amounts of olives brought by farmers to the mill and the actual production of olive oil and subsequently Zibar. The total production capacity of olive mills in Jordan is 364.4 Tons/hour. However, according to Mr. Hussiein Rqeibat; the manager of Al shu'leh olive mill in Bani Kinana District (Irbid Governorate), in the last 10-15 years olive mills have been only using 40% of their production capacity due to the reduced agricultural production of olives in Jordan and the increased number of olive mills in Jordan.

As described in Section 0 below, the MOA is given the mandate by virtue of Ministry of Agriculture Law No. 44 for the year 2002 to issue construction and operation licenses to olive mills in the whole of Jordan. MOA requires that each mill sets up a proper onsite system for collection of Zibar. MOA undertakes regular inspections to check for compliance and penalties are applied (operation in olive mill closed temporarily, olive mill pays a fine, and requested to implement corrective action; or in some cases the operational license is terminated). The mandate of MOA in relation to Zibar management ends at the onsite collection system for Zibar. Once collected and transported by tankers, Zibar is not their responsibility anymore (Further details on the institutional and regulatory framework included in Section 0).

As specified in Section 3.2 the olives season spans between mid October till end of January. During this period, olive mills operate and hence Zibar is produced. The Zibar is collected in underground concrete storage tanks. The municipal wastewater generated by the olive mill should be collected in a separate septic tank but according to discussions with several olive mill owners in the north of Jordan, some mills violate requirements and connect their internal sewer network to the Zibar tanks.

Following the end of the olives season, mills are only given one month to clean their tanks and dispose the sludge in the designated landfill.

3.6.2. PHASE 2 - TRANSPORTATION BY TANKERS

The olive mill owner agrees with a tanker to collect and transport the Zibar offsite to the designated landfill. As will be described in the text below, three landfill are specified by the Ministry of Environment for the disposal of Zibar: Ekaider for the northern governorates, AlHumra for the middle governorates, and Alajjun in Karak for the southern governorates (Figure 3). It is worth noting that Al Humra stopped receiving the Zibar due to insufficient capacity as will be explained below.

When asked, Mr. Rqeibat described that he has about a 4 tons/Hour capacity production line and three Zibar tanks for a full capacity of 250 cubic meters. Generally speaking, his mill only operates at 1.5-2 Tons/Hour. The Zibar is collected by a 16 cubic meter tanker twice each day (average 45-50 tanker trips each month) and each tanker trip charges around 55 JDs to transport the Zibar from the mill in Irbid to Ekaider in Mafraq Governorate, about ~21 km east of Irbid city and 0.5 km south of the international borders with Syria.

On the other hand, Mr. Tayseer Njdawi from Al Salt (Balqa Governorate) reports that the closest designated landfill (AlHumra landfill) has been closed by the municipality, Joint services council, and local governor due to operational and pollution issues. Based on discussions with the MoEnv, it was found that the evaporation pond established in Al Humra landfill was only sufficient for a one-season's use and not more. So, the Al Humra Landfill stopped allowing Zibar from entering the landfill. If Najdawi were to dispose the Zibar in Ekaider (more than 80 km away), tankers would charge not less than 250 JDs for each 16 cubic meter tanker trip. Mr. Najdawi produces around 50 cubic meters of Zibar each day and transporting the Zibar to Ekaider would cost more than 1000 JDs per day.

Both olive mill owners reported that given the drop in production of the mills and the increased electricity charges, the transportation fees of the Zibar are burdening their work and, together with other problems, causes the business to become unfeasible. Mr. Tayseer Njdawi from Al Salt (Balqa

Governorate) reports that each oil tin container cost him last season around 55 JDs while he sold it for 50 JDs.

To solve the Zibar problems in his mill, Mr. Najdawi excavated 4 pits in his private land and lined it with HDPE (same type used in agricultural practices). The pits have a total capacity of more than 300 cubic meters. During the olives season, he disposes of his mill's Zibar in those lined pits and leaves them to dry and turn into soft pomace/Jift to be used as heating material. However, this is a personal effort and not implemented by all mills in Al Balqa governorate (downstream management practices will be described in the subsequent bullets).

3.6.3. PHASE 3 - DISPOSAL IN THE DESIGNATED LANDFILL

A central treatment plant for Zibar does not exist in Jordan. In fact, Zibar management has been causing a lot of problems to the responsible authorities and to olive mills. The Ministry of Environment designated three landfills for the disposal of Zibar in Ekaider for the northern governorates, AlHumra for the middle governorates, and Alajjun in Karak for the southern governorates (Figure 3).

None of these can be considered as a sanitary landfill or as a proper final destination for Zibar. Actually, Ekaider has been highlighted as a hotspot in Jordan and several rehabilitation studies have been prepared to date. The latest study funded by the European and Investment Bank (EIB) as part of the Horizon 2020 Program; 'Integrated Solid Waste Management in Al-Ekaider – Jordan' has been finished and submitted beginning of 2012 to the Ministry of Planning and International Cooperation (MOPIC), Ministry of Municipalities (MOMA) and to the Irbid Joint Services Council (JSC). The proceedings and recommendations of this study as well as many others preceding this one have not been implemented on the grounds but it is no secret, Ekaider is one of the worst polluted locations and landfills in Jordan. Al Humra does not accept receiving Zibar anymore due to insufficient capacity of the evaporation ponds.

Notwithstanding the design, operational, and environmental problems of Ekaider, at least there is a system set between the 'committee for licensing of construction and operation of olive mills' of MOA and the Jordanian olive mill owners and olive oil producers union where the latter ensures that each mill has a contract with one of the designated landfills for disposal of Zibar in order to ensure that Zibar generated by the olive mills is actually disposed in the landfill and not disposed in wadis or in the sewers. The Union asks the olive mills not to pay the transportation tanker not to pay them transportation fees before the Zibar is disposed and an entry statement is brought to the mill by the tanker. The olive mill must keep these statements in order to prove that they are actually disposing their Zibar in the designated landfill and not in wadis or the sewer. However, this system is more

enforced in the northern governorates than in the middle of south but it does not fully guarantee complete compliance.

The following procedures are described for the northern governorates and based on discussions with different olive mills in the north of Jordan:

Olive mills renew their operational license yearly. As part of the documents requested by MOA for the license, a contract with Irbid JSC is required to ensure the mill has an agreement with the closest designated landfill (i.e. Ekaider). On their part, Irbid JSC issues annual permits for all waste producers/transporters of solid and liquid waste (including Zibar) in exchange for a fee based on the type of waste handled. According to the 'Integrated Solid Waste Management in Al-Ekaider – Jordan' study of 2012, Irbid JSC charges 330 JD per production line per season (between October and April) and charges 0.75 JD per cubic meter for the rest of the year. Once a contract is prepared between the olive mill and Irbid JSC, the latter provides the mill a set of 100 manifests. Each manifest is filled for one tanker trip and details to be filled include provisions for the company name, vehicle license plate number, amount of waste, date of entrance, and signature of operator. Each manifest includes three parts (one filled in by the olive mill owner and documented in the mill, one filled in by the Ekaider Landfill and documented in Irbid JSC, and the third is filled in and stamped by the Ekaider and returned by the tanker to olive mill). In essence, this cycle assists the olive mill ensure its compliance to the requirements and check for any discrepancies between amounts leaving the mill and entering the landfill. The practice in the northern governorates is that the mills do not pay the tanker before he returns the stamped part of the manifest to the mill. Sometimes there is an agreement between the olive mill owner and the tanker for payments on weekly basis. The olive mill provides the details of Zibar amounts produced during the season to the MOA as required by legislations.

According to the technical studies performed as part of the 2012 Ekaider Solid Waste Management project, the Irbid JSC provided the average daily amounts of Zibar entering the Ekaider Landfill. It has been stated that the average daily amounts of Zibar received at Ekaider are 1,381 m^3/day in 2008 but according to MOA records, 1,750 m^3/day is generated by the olive mills in the northern governorates. So this means that illegal disposal on Zibar still takes place in the northern governorates but most probably with higher monitoring and enforcement full compliance can be established. (A description of the situation in Ekaider Landfill in general and in relation to Zibar management in the landfill is included in Section 3.6.4).

For the middle and southern governorates, this system is not implemented in the same efficiency and without any monitoring or tracking to ensure compliance, the olive mills located in these governorates and the tankers resolute to discharging the Zibar in wadis, in sewers, or in the tankers

dumpsite of Ein Ghazal in Amman (Figure 3). Ein Ghazal is dedicated for tankers transporting municipal wastewater and so tankers mix Zibar with municipal wastewater and dispose their Zibar there. The wastewater collected in Ein Ghazal eventually goes to Samra WWTP that is a municipal WWTP. This is of course an illegal practice and negatively affects the operation of the WWTP.

3.6.4. ZIBAR MANAGEMENT IN EKAIDER LANDFILL

Al-Ekaider site is located in northern Jordan, in the Mafraq Governorate, about ~21 km east of Irbid city and 0.5 km south of the international borders with Syria. It is located close to the main road from Irbid to Mafraq Governorate, at about 1.2km north east of the Al-Ekaider village, which is the nearest village to the site. The mean coordinates of the site are: 36°06'E and 32°30'N. The criteria used in the site selection were the low population density and the low land cost.

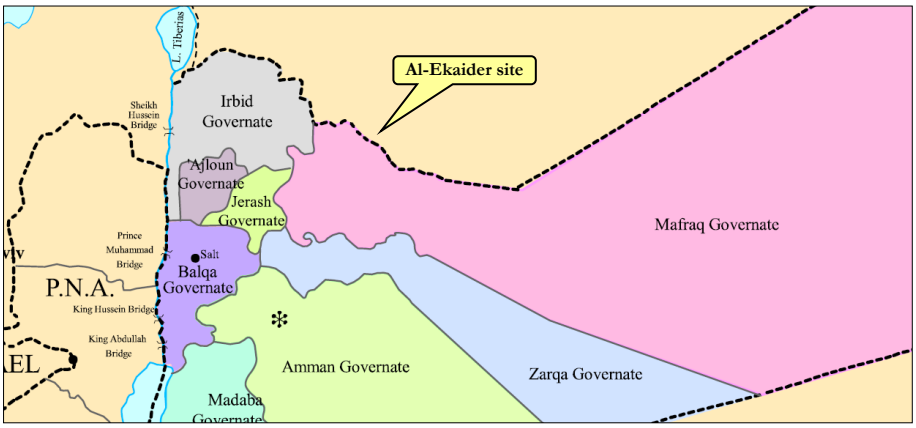


Figure 8: General location of Ekaider Landfill in Jordan

Figure 9: Location of Ekaider Landfill in the north of Jordan

Al-Ekaider Waste Dumpsite Today

Al-Ekaider is supposed to receive municipal solid waste only. However, the site is currently being used for both solid waste and wastewater disposal. Municipal WWTP sludge, Zibar, and industrial WW are discharge into earthen unlined ponds onsite (only one pond is lined as shown in Figure 10) and the mix is left to evaporate. Two discrete areas can be detected: The Al-Ekaider dumpsite (Area A), which is located in the northern part of the site; and The Al-Ekaider WW Evaporation Ponds (Area B) that cover the southern part of the site.

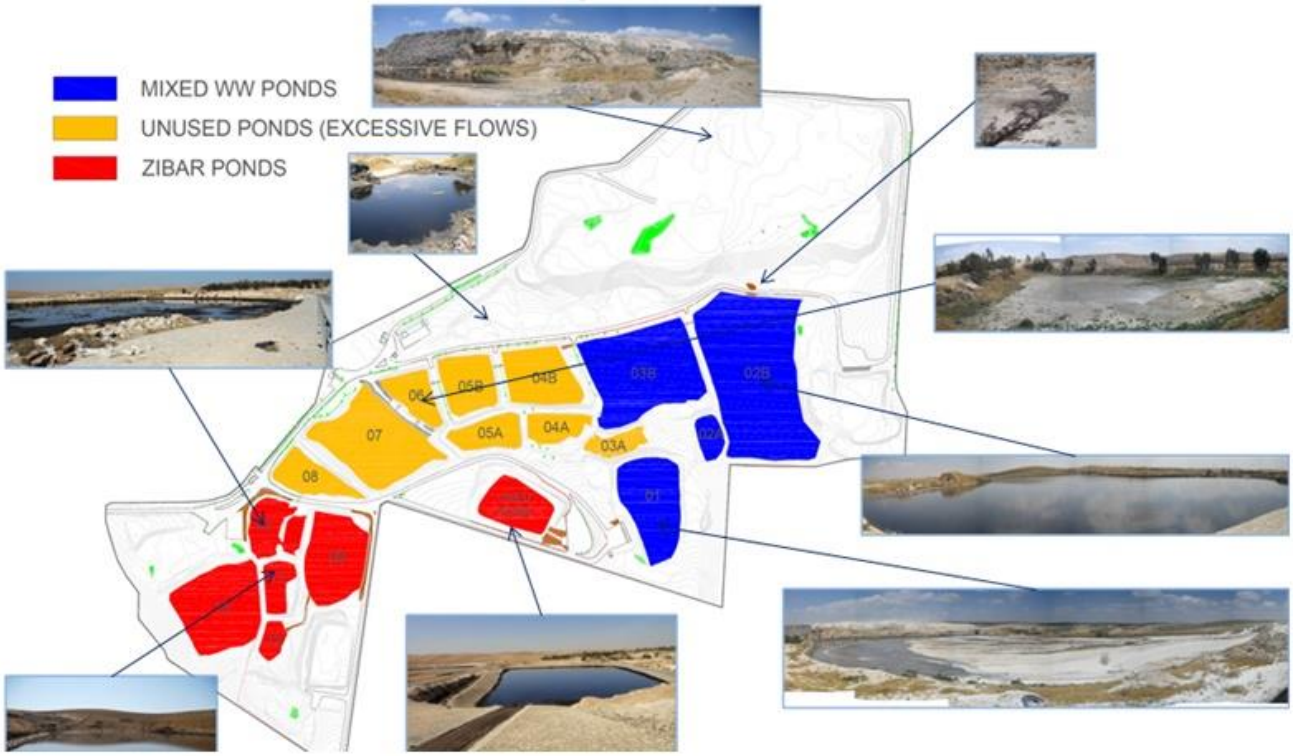


Figure 10: Site description and overview and location of Zibar evaporation ponds

About 45% of the wastewater entering Ekaider Landfill is ZIBAR (Figure 11):

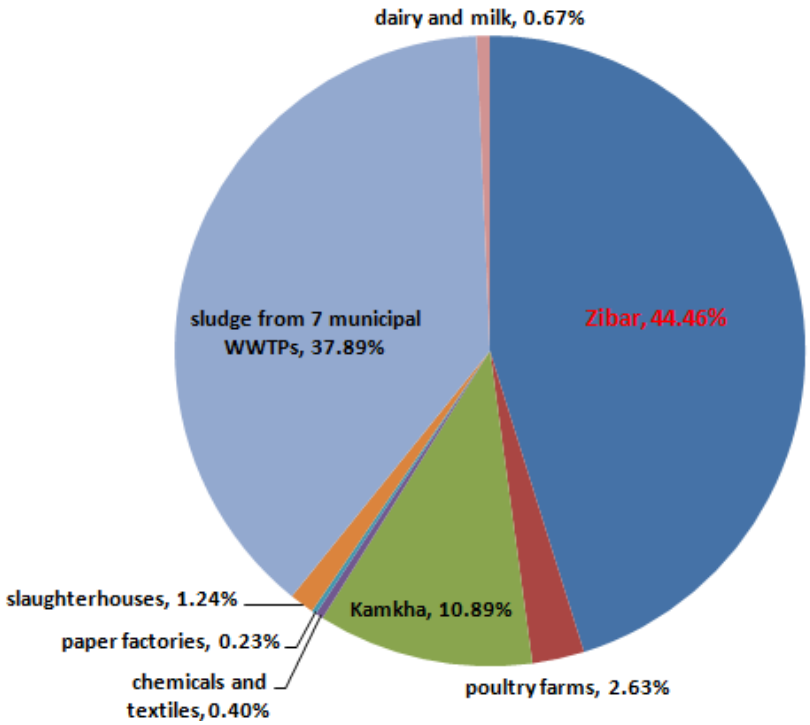


Figure 11: Sources of Wastewater being disposed in Ekaider Landfill

Even though olive mills located in the northern governorates are generally committed to sending their Zibar to Ekaider, however, the site is actually a serious hot spot and not properly managed and thus causing serious environmental and health issues (Figure 12). Below is a summary of some of the issues that are seen onsite in relation to management of Zibar:

1. 100% unsanitary landfill.
2. Lack of environmental and health protection measures.
3. Six Zibar ponds are present onsite. Five out of six are unlined and not well engineered and consequently causing serious environmental problems.
4. Five of the Zibar ponds are located in the south western corner of the landfill and at a 1.10 km distance from the closes community of Al Ekaider village. The community is always complaining and annoyed from the Zibar and phenol smell. For example, due to the odor and nuisance issues, in May of 2011, a group of Al-Ekaider village community members gathered at the entrance of the Al-Ekaider disposal and prevented access of any vehicle to the site. According to the Al-Ekaider site employees, following this incident, the Ekaider management team tried to prevent practices that caused such nuisances; in relation to the Zibar ponds, they started covering the surface with Marble Slurry Wastewater (Kamkha)

which solidifies with time and causes a shell on the surface to prevent the odor. However, this shell could also prevent evaporation of the aqueous component of Zibar.

5. Potential groundwater and surface water pollution, and soil contamination.
6. Health and Safety issues.
7. Public health and safety.
8. Deterioration of visual quality and landscape characteristics.
9. No proper management onsite and insufficient technical and financial capacity amongst the Ekaider staff.

Figure 12: Sample photos from Ekaider site that show Zibar management

On the positive side, a contract with the Irbid JSC should be made before trucks and tankers are allowed to enter the site and dispose of the solid and liquid waste, all trucks and tankers enter the site through a controlled entrance; identification should be established and the loads (waste and wastewater) are weighed and documented. As described in Section 3.6.3, the manifest system created

by the Irbid JSC is proving to be beneficial in ensuring that the Zibar generated by the olive mills in the north of Jordan (and others if they wish) actually arrives to the Ekaider Landfill and not discharged in wadis or sewers.

Tariffs for disposing Zibar in Ekaider dumpsite:

The following has been established regarding olive oil mills and Zibar in the northern governorates of Jordan:

1. Olive oil industry in the northern parts of Jordan is mostly small businesses and cooperatives with limited ability to pay and highly dependent on the seasonal produce of olives.
2. As per discussions with several olive mill owners and to the calculations shown above, the mills from the northern governorates produce round 1,400 m3/day. Based on the numbers of mills in the north of Jordan (MOA-2013) it is concluded that on average, each of the 90 mills in the north produce around 16-20 m3/day of Zibar from a 1 ton/day production line during the olives season (i.e. each mill produces around 1700 m3/season of Zibar).
3. The fee paid for Zibar disposal by mill operators is currently 330 JOD/production line/season. There is no link with actual quantities of Zibar brought to Al-Ekaider. To match the Zibar production estimates in m3/year, the current fee has been interpreted to 0.2 JOD per m3, based on estimated 1,700 m3/season average quantities generated by each mill and disposed in Ekaider.
4. The mills also need to pay the tankers to send their Zibar to its final destination at Ekaider dumpsite. According to discussions with the olive mill owners, for a production line of 1 tons/day the mill pays around 450-500 JDs per week for transportation tankers to dispose the Zibar in Ekaider (i.e. 6,500 JD per season for a mill with 1 ton/day production line) which translated into 3.8 JD/m3 of Zibar.
5. The mills also reported that one third of their income is spent on operational costs at the mill (electricity, maintenance...etc)
6. The profitability of olive mills has dropped significantly especially that the annual rainfall has declined significantly in the whole of Jordan over the past ten years or so, which affected the amount of olives and olive oil produce in Jordan.
7. On different occasions, the Irbid JSC planned to increase the fees for Zibar disposal in Ekaider landfill but the olive mill owners did not accept to pay and protested till Irbid JSC refrained from the increase in the fees. This indicates unwillingness to pay any additional fees for disposing their Zibar in Ekaider.

4. LEGAL AND INSTITUTIONAL FRAMEWORK

The Zibar management chain starts at generation and storage of Zibar in the olive mill, and ends at the final disposal site. Between the two is the transportation of the Zibar by tankers. Different institutions and mandates are involved in regulating the management process in general but not all are liable to each phase of the chain. In order to shed light on this setup, this section will discuss and identify the legal and institutional setup for each phase of the management chain (Table 8).

Additionally, some questions could be raised, for example:

- *Is there one entity responsible for the whole process from cradle to grave?*
- *Is there any difference between the mandate and what is actually implemented on the grounds?*
- *Is there enough inspection to ensure compliance?*
- *Are there any overlaps or gaps in the legal and institutional setup?*
- *If a solution is to be planned for the Zibar problem, who can be the champion to lead and take responsibility for its planning and also for the implementation?*

This Section will introduce the legal and institutional framework that governs Zibar management in Jordan. These questions as well as others will be answered throughout this section and so pave the way to all needed decisions on technical and operational improvements.

4.1. LEGAL AND ACTUAL OPERATIONS AND ACTIVITIES IN RELATION TO ZIBAR MANAGEMENT

The overarching objective of this master plan for Zibar management is to understand the existing issues in order to come up with a technical and financially feasible solution for Zibar management in Jordan. In order to help achieve that in terms of the institutional and legal setup, the previously described management processes of Zibar in Jordan have been broken down into the constituent activities which take place throughout the Zibar management chain.

Two scenarios are given for the Zibar management activities; the compliant scenario (or Legal Operations and Activities) which is identified based on a review of the legal options for management

as well as the international best practice. The second scenario is the non-compliant scenario (or Actual Operations and Activities) and this is identified based on review of different reports that discuss the Zibar management in Jordan, discussions with olive mill owners in Jordan, discussions with the related directorates within the MOA and the MoEnv, and expertise from similar previous work and projects.

Table 7 below describes the activities under the compliant and non-compliance management scenarios (or as referred to in the table: Legal and Actual Operations and Activities in Relation to Zibar Management).

Table 7: Legal and Actual Operations and Activities in Relation to Zibar Management

Phase	Responsibility	Legal Operations and Activities	Actual Operations and Activities
Phase 1 - The Olive Mill	The olive mill owner	1. Planning, design, and licensing (construction and operation license) of the olive mill 2. Emptying and cleaning the Zibar storage tanks and transferring the water to a tanker for transportation before the start of the olives season in order to have the tanks ready to receive the newly generated Zibar 3. Setting up an agreement with the nearest designated landfill for final disposal of Zibar (Section 3.6.3). 4. Renewal of operation license (license valid from 1 Oct till 30 September) 5. Opening the mill during the olives season as per the timeframe set for the season (the timeframe is set for each year according to the season and production, e.g. 2013 season has been set to start on the 15th of Oct by MOA) 6. Commencement of the olives season and the oil extraction processes 7. Generation of Zibar and its storage in the storage tanks 8. Coordination with a tanker to empty the tank at a certain rate (e.g. once or twice each day depending on the production capacity and actual oil production in the mill) and ensure that it is being disposed in the designated landfill 9. Emptying and cleaning of the Zibar storage tanks	1. Operation of the olive mill without a license. OR Changing, modifying, or expanding the operation lines in the mill without a license. 2. Installing and using improper Zibar storage tanks (e.g. permeable from the bottom or/& sides, uncovered, no opening in the cover to allow for aeration or cleaning, insufficient capacity to mirror the production capacity of the mill…etc). 3. Emptying the Zibar storage tanks and random disposal on the grounds of the olive mill or outside its boundaries. 4. Operating the mill without having an agreement with a designated landfill for disposal of Zibar or having an agreement for licensing purposes only and not for actual implementation. 5. Random disposal of Zibar on the grounds of the olive mill or

Phase	Responsibility	Legal Operations and Activities	Actual Operations and Activities
			outside its boundaries, OR overfilling of the Zibar storage tanks due to insufficient capacity. 6. Coordination with a tanker to empty the tank at a certain rate (e.g. once or twice each day depending on the production capacity and actual oil production in the mill) and agree (explicitly or implicitly) on disposal of the Zibar in the wadis or in the sewer network without any treatment.
Phase 2 - Transportation by Tankers	The transportation tanker and potentially the olive mill owner	1. Collecting the Zibar from the olive mill 2. Transporting the Zibar to the nearest designated landfill	1. Collecting the Zibar from the olive mill 2. Transporting the Zibar and disposing it in wadis or in the sewer network without any treatment.
Phase 3 - Disposal in the Designated Landfill	The transportation tanker and potentially the olive mill owner	1. Disposal of Zibar in the designated landfill	1. Disposal of Zibar in a non-designated landfill 2. Illegal disposal and not reaching the designated landfill in the first place

4.2. Legal and Institutional framework in Relation to Zibar Management

Based on the legal and actual activities provided in Table 7 above, the relevant legal and institutional setups are identified.

Table 8: Legal and Institutional setup that govern Zibar management in Jordan

Phase	Responsible Entity	Mandate	Stipulations
Phase 1 - The Olive Mill	Ministry of Agriculture	Agriculture Law No. 44 for the year 22	• This Law makes the Ministry of Agriculture (MOA) responsible for overseeing the agricultural sector. This responsibility includes wide-ranging environmental aspects such as managing forests, regulating hunting, the protection of wildlife and licensing the commercial exploitation of wildlife. • In relation to olives and olive mills (or presses as per the Law), Article (16) of the Law stipulates the following: 1. Establishment and operation of Olive presses in Jordan requires a license from MOA. 2. Specific instruction in relation to licensing of olive presses are issued by MOA to regulate the olive presses technical and health conditions, operation dates, the registers to be kept by the owner and provision of the information. 3. Non compliant olive presses are penalized with a fine of no less than (five hundred JD, but not exceeding (one thousand JD). 4. Repetition of violations causes the fine to double in amount. Further repetition ensues in closing down the press for a period of one month in addition to doubling the fine.
		Licensing for construction and operation of olive mills in Jordan is regulated by the MOA according to Instructions No. 15 for the year 2012	• This instruction regulates licensing for construction and operation of olive mills in Jordan. The instructions identify the Zibar as the liquid material resulting from the olive oil extraction process in addition to the water added during the extraction process to assist the extraction of oil from olives. • A committee for licensing of construction and operation of olive mills (first-time license, renewal, addition of lines to an already existing olive mill, modifying or upgrading existing lines in an already existing olive mill, and relocation of an olive mill to another location) is formulated by a decision from minister of MOA. The committee is lead by the head of olives directorate in the ministry with representative members as follows: head of olive mills licensing section (MOA), Ministry of Water and Irrigation (MWI), Ministry of Health (MOH), Ministry of Municipal Affairs (MOMA), Ministry of Environment (MoEnv), and the Jordanian olive mill owners and olive oil producers union. • The following is a list of licensing requirements set by MOA to ensure proper management of the Zibar is taken into account in the design and construction of the mill: 1. Olive mills are not allowed to be constructed within 350 meters of major wadis and within 25 meters of secondary wadis 2. For each one production line of a 1 ton/hour production capacity, the olive mill shall construct two underground concrete storage tanks with a capacity not less than 60 cubic meters for each tank. The ZIBAR shall flow from the first storage tank to the other. For each additional 1 ton/hour capacity production line, an additional underground concrete storage tank with a capacity not less than 60 cubic meters shall be installed. The tanks shall be concrete, Solid and impermeable for the bottom and sides, has a cement or metal cover, several openings must be left in the tank cover to allow for aeration and with sufficient dimensions that permit regular cleaning. 3. Proper drawings from an accredited engineering firm should be presented to MOA for licensing purposes. • As for the operational requirements that are related to Zibar, these are listed below: 1. Olive mill owner shall present to MOA a technical report and as-built drawings from an accredited engineering office that proves the construction of the underground concrete storage tanks according to requirements and under the office's supervision. 2. Collection and disposal of the Zibar in an accredited landfill designated for this purpose during the olives season and upto only one month after end of the season. 3. The olive mill shall not dispose of the Zibar in wadis, sewers and wastewater networks, and soil pits during or after the season. The Zibar shall be disposed of in an accredited and designated landfill in coordination with the local governors in the governorates and districts. 4. The olive mill owner shall follow the requirements and specifications stipulated by the relevant authorities (Ministry of Water and Irrigation, Water Authority of Jordan, Ministry of Environment, Ministry of Health) if he wishes to establish an Zibar treatment plant onsite. 5. Operational license is granted to compliant olive mills and is renewed yearly. According to MOA, the license is given to all mills from 1st

Phase	Responsible Entity	Mandate	Stipulations
			October till 30th September of the following year to mirror the olives season and insure that all environmental and health requirements of the instructions are applied by the mills. For new mills, the license is given from the date of granting the license and ends in the forthcoming 30th September. For renewal of the licenses, a committee formed by representatives from MOA and from other ministries (Water, Health, and Environment) inspects the olive mills and ensures that all requirements are met and ready to receive the upcoming season. The committee also checks the underground concrete storage tank and ensures that the Zibar is emptied and that the tanks are cleaned. If that is not the case, the license is not renewed unless corrective action is made by the olive mill owner. 6. If the mill does not commit to the environmental and health requirements during its operation, the committee has the right to suspend the operational license (even if it is still valid). 7. MOA decides the start of the olives season each year based on the production of each season and the climate of the area within Jordan. Mills are not allowed to operate before the date set by MOA. 8. Each mill should keep a manifest of amount of olives entering the mill and the amounts of produced olive oil. Additionally, the mill should keep a manifest of the produced amounts of Zibar and Pomace/Jift.
Phase 2 - Transportation by Tankers **and** **Phase 3 - Disposal in the Designated Landfill**	Ministry of Environment	Environmental Protection Law No. 52 of 2006	• The Environmental Protection Law No. 52/2006 states that MoEnv is the official national body accountable for the protection of the environment and its components namely: air quality, water, soil, biodiversity and human beings. • The provisions of article (3) within the "Environmental Protection Law No. 52/2006" stipulate that all official entities should abide to the environmental requirements stated by the MoEnv. Moreover, MoEnv is also mandated to collaborate with respective local, regional and international entities for environmental protection and pollution prevention (articles 4 and 5 within the Environmental Protection Law). • MoEnv's responsibilities according to the Law include, but are not limited to the following: Setting of necessary policies and plans for environmental protection; and Issuance of specifications for environmental quality objectives, which shall serve in the processes of licensing and license renewal. • The specifications to be issued by MoEnv take into account handling of hazardous substances and their final disposal among others.
		Soil Protection Regulation (No 25, 2008)	• MoEnv in coordination with MOA is empowered to establish special zones for the protection and development of certain types of plants with soil stabilization properties. • Article (3) requires "Monitor sources of soil pollution and control to the environmentally allowable limits, commensurate with the locally adopted standards". • It further specifies that the criteria for instruments used in the disposal, management and handling of hazardous waste require that wastewater and solid waste should be separated and not in mixed form.
		Instruction for Hazardous Waste Management and Handling (2003).	• The Instruction defines harmful and hazardous substances and waste as "any substances that cannot be disposed of in the dumping sites designated for general waste, or into drainage networks, due to their hazardous characteristics and their harmful effects on the environment and life forms, and which require special means to treat and permanently dispose of". • The preparation of technical and other specification related to the different stages of the management of hazardous substances and waste are delegated to a Technical Committee chaired by Secretary General of the MoEnv (members of this technical committee are listed within the Regulation). The responsibilities of this Technical Committee are also provided in the Regulation, which further provides the requirements to be granted authorization for dealing with hazardous substances and waste. • No entity dealing in waste and hazardous and harmful substances in any manner may conduct its operations except after obtaining an authorization from the Minister, upon the recommendation of the Secretary General, which is based on the Committee's recommendation

Phase	Responsible Entity	Mandate	Stipulations
			• An entity obtaining an authorization to deal with hazardous and harmful waste shall comply with different requirements (e.g. Treat and dispose of hazardous and harmful waste in the designated sites specified and in accordance with the programs set by the Ministry for this purpose.) • Article 4 of the Instruction indicates that the conditions of storage and disposal of hazardous wastes include: lining the area to be used for the landfill so that they system of lining to prevent leakage of waste into the soil layers beneath the liner or to the water sources (GW or surface) during the operational phase of the landfill.
		Regulation for environmental monitoring and inspections No. 65 for 2009	• Describes and guides the inspection process to ensure environmental protection of all environmental attributes, that the legislation is correctly enforced, and that information management programs are developed to facilitate decision making and the analysis of environmental data. All projects which might impact the environment should be subject to monitoring programs.
		Instructions for categorizing industrial establishments according to the risk on the environment	• Industrial establishments are categorised into three groups • Group 1 are those that have high risk of pollution and that have significant impacts on the environment and human health. These require special prevention or/and mitigation measures. • Establishments that produce waste and wastewater of high or low acidity and also that generate (treated) wastewater of quality in exceedance of the relevant legislations are categorised as Group 1. The risk of such entities increase if located in the vicinity of natural resources (water resources, agricultural land, …etc) • Specific forms for each group are prepared by the MoEnv for inspection and follow up.
	Environmental Rangers – Jordan Civil Defense	Memorandum of Understanding between MoEnv and Civil Defense	• This MOU enables the Environmental Rangers to work according to their civil defense legislations in addtion to the stipulaions of the Environmental Protection Law and other environmental legislations • The Environmental Rangers are authorized to stop and penalize any vehicle/tankers causing any pollution (e.g. random waste/wastewater disposal)
	Ministry of Health	Public Health Law No. 47 for the year 2008	• Articles 21 and 46a of the Law stipulates that its role is to monitor the working environment and its compliance with the related legislation, in addition to ensuring employees healthy working conditions. It also regulates wastewater as well as monitors wastewater treatment plants and their conformance with the relevant national legislations. • It also prohibits under penalty of legal liability events or accidents causing unsanitary conditions, including improper handling and/or disposal of solid, liquid or other waste. • Article 46 (a) in particular states that dumping the contents of septic tanks in places other than those designated for that purpose and the discharge of wastewater from the collection and treatment plants without being properly treated are both considered as health nuisances and hazard. • "Article 47 of the Public Health Law 47 for 2008" defines the causes of health nuisances. One of the defined causes is wastewater which does not meet the required standards (whether untreated or insufficiently treated).

Phase	Responsible Entity	Mandate	Stipulations
			• Article 51 stipulates that MOH shall, in coordination with the relevant authorities and in conformity with its own legislations, control the Sewage water, the Sewage networks, the internal installation, and the treatment stations, in order to ensure the availability of health conditions therein and guarantee that no harm would be caused thereby to the public health, and if it becomes evident to the ministry that the Sewage water, the networks, the installations, or the treatment station constitute or may constitute a threat to public health, then it must take all the necessary measures to prevent the occurrence of the anticipated detriment to health. • Article 62 C2 stipulates that disposal of the contents of septic tanks and wastewater tankers in locations other than those designated by authorized entities for this purpose as well as the discharge of wastewater from treatment plants prior to its final treatment are penalized with imprisonment for no less than three months and no more than a year and with a sanction no less than a thousand Jordanian dinars and no more than three thousand Jordanian dinars or both. The Court has the legal mandate to shut down the location where violations have taken place.
	Ministry of Water/Water Authority of Jordan	Water Authority Law No. 18 for 1988 and it's amendments thereof	• The Ministry shall carry the full responsibility for all water and wastewater systems and the related projects and shall set forth a water policy and submit it to the Council of Ministers for approval. • MWI and WAJ are some of the key entities involved in the water sector. There is a difference between the functions and responsibilities assigned to each entity as follows: MWI's role is mainly planning for the water sector (refer to articles 4 and 10 within Regulation 54 for 1992 and article 5 of the Water Authority Law No. 18 for 1988 and it's amendments), and WAJ assumes all the responsibilities related to water and wastewater structures; their design, construction, operation, maintenance and administration (article 6 of the Water Authority Law No. 18 for 1988). • In order to achieve all the objectives intended by this Law the Authority shall exercise the following responsibilities and tasks in relation to wastewater management: Study, design, construct, operate, maintain, and administer water and public wastewater projects including collecting, purifying, treating, disposing of water and wastewater, and the methods of dealing with water; Draw terms, standards and special requirements in relation to the preservation of water and Water basins, protect them from pollution, and ascertain the safety of water and wastewater structures, public and private distribution and disposal networks, and take the necessary action to ensure technical control and supervision, including, all necessary tests; and Carry out theoretical-and applied research and studies regarding water and public wastewater to achieve the Authority's objectives including the preparation of approved water quality standards for different uses and technical specifications concerning materials and construction in order to apply the findings to the Authority's projects in coordination with other concerned departments; and publish the final findings and standards so as to generalize their application by all means available to the Authority. • Article 23 A) With regard to the contents of paragraph (b) of this Article, all duties, responsibilities and obligations related to water and public sewerage , which were previously the responsibility of any governmental department, corporation or any public commission or municipality, shall be transferred to the Authority. • Article 30 of the Law states that anyone shall be sentenced to no less than six months, and no more than two years imprisonment or to a fine no less than 1000 JD and no more than 5000 JD, or both punishments if has committed any of the following acts: 1. Caused damage to any of the Authority's projects or ruined or destroyed any water resources or the Authority's public sewers or acted in a way that may cause the damage or destruction of construction, equipment, vehicles or materials related to the Authority or any of its projects or public sewers. 2. Polluted any water resource, which is under the management or supervision of the Authority directly or indirectly, or caused its pollution and failed to remove the causes thereof within the period fixed by the authority.
		Administrative	• Ministry shall assume full responsibility for water and public sewage in the Kingdom as well as the projects pertaining thereto, formulation and

Phase	Responsible Entity	Mandate	Stipulations
		Organization of the Ministry of Water & Irrigation No. 54 for the Year 1992	transmission of the water policy to the Council of Ministers for adoption.
		Regulation for the Determination of Groundwater Protection Zones for 2005	• The groundwater is state owned and it is subject to its control. Article 6 of the paragraph e "Draw terms, standards and special requirements in relation to the preservation of water basins, protect them from pollution, and ascertain the safety of water and wastewater structures, public and private distribution and disposal networks, and take the necessary action to ensure technical control and supervision, including all necessary tests".
		Sewerage Systems Regulation No. 66 for 1994 and its amendments thereof	• Article 3: It is forbidden for anyone to discharge any wastes and liquids other than sludge into the public sewerage system. The Authority issues instructions which are to be published in the official gazette; those instructions determine substances, liquids and wastes which are banned from disposal within this article. • Article 5: The Authority has the right to run accredited laboratory tests every once in a while on samples obtained from wastes and liquids flowing in any public or private stream. • Article 6: It is forbidden for anyone to discharge any liquid wastes or polluted or regular water into water resources prior to its treatment. Furthermore, a written permit should be obtained from the Authority for discharging such water with reference to the accredited Jordanian standards and specifications. • Article 8 (a): A. In case it was not possible to connect a private sewerage network to the public sewerage network for any given reason, the owner shall construct a septic tank on his own cost and limited to the area of his facility; this should be done in compliance to standards and instructions approved by the Local Committee in collaboration with the Authority in certain locations designated for such purposes. Furthermore, the owner should discharge the contents of these septic tanks in accordance to the specifications set by the Authority.
		Instructions for the discharge of industrial and commercial wastewater into the sewerage network for the year 1998	• Article 2: discharge of contaminated and non-contaminated industrial and commercial wastewater to the sewer network is not allowed unless a written approval is attained from the Authority in accordance to these instructions • Describes what substances cannot be discharged into the sewage system and the quality of wastewater for industries connected to the sewage system (Table 5).
	Ministry of Municipal	Prevention of Health Nuisances	• Article 6: It is prohibited on anyone to cause any nuisance from those set forth in this regulation within the municipal area • Article 4 F&H: To fulfill the intended goals of this regulation, the following are considered nuisances: 1. Wastes, wastewater, machines, junk, wood or empty containers or any other things disposed of onto streets or walkways or any other area in a

Phase	Responsible Entity	Mandate	Stipulations
	Affairs	Regulation 1-1978 and its amendments No. 72 for 2009	way that poses risk or harms public health. 2. The discharge of the contents of septic tanks, sewer or wastewater tankers in locations other than those assigned for these purposes.
	Greater Amman Municipality (within the borders of Amman)	Prevention of Health Nuisances Regulation No. 83 for 2009	• To fulfill the intended goals of this regulation, the following are considered nuisances: 1. The establishment of any facility or using it in a manner that harms the public health. 2. Creating any hole, stream, water basin, sink, well, latrine, waste disposal site, a smokestack, bakery, furnace or anything similar to the above harmful to the public health or keeping it in a way that poses a threat to the public health 3. Disposal of water, wastes, dirt, soil and construction demolition wastes, machinery, scrap, wood, containers or anything else onto streets or sidewalks or anywhere else in a way that harms public health. 4. Discharging or leaving behind the contents of septic tanks, sewerage networks or wastewater transportation tankers in locations other than those designated by the Counsel for this purpose. 5. Emptying the contents of septic tanks through blasting the surface or the side of the septic tank and disposing of its content within the property borders or in the public sewerage network or rainfall drainage network.
	Jordan Institute for Standards and Meteorology	Standards and meteorology law No.(22)/2000	• This law entitles JISM to monitor facilities, to ensure that they are complying with their standards
		Industrial reclaimed waste water JS 202:2007	• States what are the standards of the industrial wastewater discharged into wadis, water courses and water bodies (Table 5). • It also states the frequency of sampling according to its reuse purpose

4.3. INSTITUTIONAL FRAMEWORK

The institutional framework that governs Zibar Management in Jordan comprises of three two institutional levels; one is applicable at the first phase of the Zibar management chain, and the second is applicable for the rest of the phases. These institutional levels are indicated below:

1. Phase 1 - The Olive Mill:

- The MOA assumes its responsibilities at this phase in relation to licensing, inspection, monitoring Zibar management onsite, and general compliance to MOA instructions.
- Other entities can inspect the olive mill in relation to Zibar management onsite. Objectives for which environmental inspections are carried out differ according to the entity conducting them. These objectives are as follows: protection of water resources and of the wastewater network and treatment plant (WAJ, and MOH); securing residential, domestic and irrigation water supplies by ensuring compliance to standards and specifications (WAJ, and MOH); and protection of public health through the prevention of health nuisances (MOH, and MOMA/GAM) and ensuring the sustainability of wastewater treatment plants and sewerage networks (WAJ). However, since MOA is fully responsible for this phase, then the other entities do not actually monitor compliance at this phase. In the same time, these entities have representatives in the committee for licensing of construction and operation of olive mills that participates in the licensing process and site inspection.

2. Phase 2 - Transportation by Tankers

- Monitoring transportation by tankers: Tracking of industrial wastewater tankers including those carrying Zibar are assumed to be the responsibility of the MoEnv but that is not actually implemented by MoEnv on the ground.
- The MoEnv mandate is delegated to the Environmental Rangers within certain procedures as described in their agreed MOU. Based on the Environmental Rangers tasks, they can penalize tankers that discharge the Zibar into Wadis or in the sewers. So actually the Rangers perform MoEnv tasks on the ground. However, they are not expected to stop a tanker and ensure compliance if no violation is actually performed by the tanker.
- Discharge of Zibar into wadis: MoEnv, MoH and MOMA (or GAM) are the entities that conduct inspections for the following objectives (respectively): ensuring protection of environmental resources with water being among them, protection of public health and of drinking (only) water resources, and prevention of nuisances.
- Discharge of Zibar in to the Sewer network: WAJ assumes the responsibility of inspecting wastewater discharged into the sewerage system with the purpose of protecting and maintaining their wastewater infrastructure. However, since WAJ claims to be only liable for

wastewater that flows in their sewerage network and eventually goes to their WWTP, then they are not involved in regulating wastewater discharged into wadis. That is expected to be done by MoEnv, and MOH only in case there is a direct impact on drinking water resources.

3. Phase 3 - Disposal in the Designated Landfill

- MOMA or the Joint Services Council responsible for managing the landfills designated for Zibar disposal. The only landfills operating at the moment are Ekaider and Lajjun. However, Lajjun is not actually used by the mills outside Karak governorate due to low level of enforcement and distance and consequently the transportation costs.

4.4. Institutional Deficiencies

1. **Policy aspects:**

- Lack of a clear policy that is focused Zibar management. This has caused an overall deterioration of Zibar management in Jordan. Further increasing this variation is the lack of unified legislation in the olive oil producing countries.
- Lack of guidelines, manual and operational standards for Zibar management.
- Absence of legislation for establishment of standards and specifications for Zibar management.
- Tariffs for disposing Zibar in Ekaider landfill are set arbitrarily based on negotiated prices with olive mills and are not reflective of, or correlated to, the actual cost of managing Zibar within Ekaider.
- Strategic planning criteria have not been integrated into the planning process and the permits for establishment of new mills (e.g. hydrological sensitivity and proximity to potable water reservoirs and to composting facilities).

2. **Sector Standards and Guidelines:**

- No specific legislations govern the management of Zibar from cradle to grave except for the MOA instructions that regulate licensing of mills. Jordan has been among the olive oil producing countries for ages now and yet, there is no regional government that owns the management process of Zibar and there are not even legislations that put things in order. Alternatively, a unified agreement must be reached between entities in terms of interrelated responsibilities and coherence of inspection priorities and enforcement policy in order to lead to better management, water saving and protection of the environment in all producing countries.
- There are no specific technical standards for Zibar, but there are specific standards for receptor (sewers, wadis, and irrigation).

- The prevention of pollution caused by the discharge of Zibar covers three potential discharge scenarios; Zibar discharged into wadis and water courses; the Zibar discharged into the sewerage system, and the Zibar transported by tankers. In all three scenarios, there is no specific legislation that regulates the discharge of Zibar. Based on its quality, Zibar is assumed by authorities to follow the industrial wastewater legislations and Jordanian Standards (i.e. WAJ Instructions for discharge of industrial and commercial wastewater to the sewer system for the year 1998, and JS 202-2007 Industrial Reclaimed Wastewater). Nevertheless, many of the legislations indirectly related to Zibar as covered in Table 8 are only drafted using broad terms that do not clearly state the degree of involvement of different entities. Hence, leading to speculations regarding who shall conduct the inspection in terms of industrial wastewater, let alone Zibar.
- Not all industrial facilities are connected to the sewer network or have onsite industrial wastewater treatment units. Hence, they have no other option but to use tankers as transportation means for their wastewater from their point of generation to the allocated industrial wastewater treatment plant. Relevant legislations touch upon the issue of tankers transporting such industrial wastewater without providing any details on who is to conduct inspections and what parameters should be covered to ensure safety during transportation and also ensure compliance.
- Ministry of Environment: according to Article 4 of the 'Environmental Protection Law No. 52 for 2006', MoEnv is entitled to interfere in issuing standards and parameters as well as monitoring "environmental components" (water being defined as one of these components in Article 2). Nevertheless, since its establishment in 2003, MoEnv's exact role when it comes to the water and wastewater sector is subject to a lot of speculations. This is mainly because these components are broadly defined within "Article 2" without clear specification of when and to what extent MoEnv is involved.

3. Actual implementation Issues:

- MOA and MoEnv officials report that they struggle to find an environmentally friendly and economically feasible disposal method for Zibar. Officials report that the Government does not have the funds to establish a central treatment plant or a common disposal facility for Zibar in Jordan.
- Insufficient legislations as well as weak enforcement multiplied with the incapability of mills to support an engineered solution and the lack a well-practiced cost efficient end solution, together, create the enabling environment for illegal dumping of Zibar to wadis and sewers as currently practiced in Jordan.

- On the ground, MoEnv does have the logistical and financial capacity to conduct regular inspections on discharge of neither industrial wastewater nor Zibar in Jordan and thus only conducts "upon-complaint" inspections. Hence, MoEnv are liable by law to enforce environmental protection but on the ground, this is not implemented in full. The Environmental Rangers support the MoEnv in their duties but, based on discussions, it seems that there is no proper communication and updates between the Rangers and the MoEnv.
- Furthermore, MoH does not conduct any inspections within the water sector unless for water assigned for drinking purposes therefore, MoH delegates the responsibility of inspections on industrial wastewater onto the entities it considers in charge; those being MoEnv, MWI, WAJ and MOMA (and GAM).
- The Ministry of Water and Irrigation (MWI) and the Water Authority of Jordan (WAJ) on the other hand have the following responsibilities in relation to wastewater: MWI's role is mainly planning for the water and wastewater sector, and WAJ as the implementation arm of MWI assumes all the responsibilities related to water and wastewater structures; their design, construction, operation, maintenance and administration. Accordingly, WAJ should study and plan for solutions for Zibar treatment and construct the preferred Zibar treatment scheme; but they do not. Also, WAJ assumes the responsibility of inspecting wastewater discharged into the sewerage system with the purpose of protecting and maintaining their wastewater infrastructure. On the grounds, the MWI/WAJ staff when asked, they claim that their responsibility is only implementation of wastewater project (network, pumps, WWTP …etc) for municipal wastewater only and not any other type of wastewater (Industrial, Zibar…etc).
- Since no legislations govern Zibar management and this is aggravated by the lack of clear legislations that address the issue of inspections carried out on tankers transporting Zibar from the point of generation to the allocated industrial wastewater treatment plant as well as the weak inspection and enforcement, most the tankers transporting Zibar in the middle and south of Jordan end up discharging their load into the nearest valley or into the Ein Ghazal "tankers dumping yard" (Figure 3) which is designated for discharge of municipal wastewater only. Tracking of industrial wastewater tankers is assumed to be the responsibility of the MoEnv but that is not actually implemented by MoEnv on the ground.
- Generally, olive mills in the north of Jordan do send their Zibar to Ekaider. However, Ekaider is in a really bad shape and is an actual environmental disaster. Olive mill owners agree that if a proper final disposal for Zibar were to be established by the responsible government entity, then they will have to comply. But they do not see the current situation in

Ekaider as a convincing motive for them to comply. Most of the mills in the north comply by sending their Zibar to Ekaider only because they need to in order to get the operation license.

- Apart from lacking the financial resources, many mill owners are unaware of the environmental damage they are causing. There is a lack of education as to why and how Zibar needs to be dealt with, so in general, mill owners release the waste water not realizing it will harm their land as well as the wider environment. When asked, olive mill owners claim that tankers come at night and dump their wastewater outside towns damaging crops and causing a bad smell.
- Lack of awareness amongst olive mill owners and olive oil producers in relation to the substantial environmental damages caused by illegal dumping of Zibar.

5. AVAILABLE TECHNOLOGIES FOR TREATMENT OF ZIBAR

The difficulties of Zibar treatment are mainly related to high organic loading, seasonal operation/generation, high territorial scattering, and the presence of organic compounds which are hard to biodegrade such as long-chain fatty acids and phenolic compounds.

The problem of Zibar management and treatment has undergone extensive study during many years in the different olive oil producing countries and many possible solutions have been considered. However, due to lack of financial means as well as lack of knowledge and know-how, it may not be financially and technically feasible to implement such treatment options in small and medium olive mills.

Since Olive oil industry in Jordan is mostly small businesses and cooperatives with limited ability to pay and highly dependent on the seasonal produce of olives, therefore, a downstream centralized treatment plant for Zibar is more suitable than upstream treatment options. It would be more sensible to place such environmentally acceptable downstream solutions for the Zibar issues in areas with high density of mills; which is the northern part of Jordan as already established throughout the text.

Without such solution and technology, the pollution from olive oil processing will lead to greater ecological problems as well as cause potential substantial damage to the wastewater network and municipal wastewater treatment plants.

The issue of Zibar management, treatment, and illegal disposal has been discussed by authorities many times and no actual solution has been put on the table. It is about time, and actually urgently needed, to create linkages between up- and downstream activities and implement a once and for all solution that solves this problem by considering suitable alternatives for treatment and management of Zibar.

Note: the text below has been formulated based on literature review of different technologies for treatment of Zibar used in some olive oil producing countries.

5.1. TECHNOLOGIES AND METHODS OF ZIBAR TREATMENT

Different methods can be used for treatment of Zibar but the final selection of a suitable method depends partly on the applicable technical standards. As already indicated, in Jordan, there are no specific technical standards for Zibar but only for industrial wastewater in relation to the receiving environment.

Other criteria are important and should be considered when studying the potential treatment options for Zibar treatment. These include the following:

1. Information about the olive mills: Capacity (maximum production and working capacity) in ton/hour, quantity of processed olives (ton/hour) or ton/year, olive oil produced in ton/year
2. information about the solid residues: Pomace quantity in ton/year or ton/ton olive, Moisture in %, Nitrogen content, Potassium content, Olive oil residues content, Stone content, and Fiber content in % d.w., Extraction of pomace oil, Used for compost, Animal feed, Spreading on soil, Burning as fuel and Stones burning in % of total solid residue.
3. Information about the liquid waste: Vegetation wastewater quantity in m^3/year or in m^3/ton olive, BOD5 in mg O2/l, COD in mg O2/l, Phenoles/poliphenoles in mg/l, Nitrogen in mg/l, Potassium in mg/l, Phosphorus in mg/l, TS in mg/l, pH, Oil content in %, Organic matter and Mineral matter in % d.w., Electrical conductivity in dS/m, Lipids in mg/l, To purify, To spread on cultivated oil, To compost in % of total liquid waste, Energy and water consumption, Wash water in m^3/ton olive, Process Water in m^3/ton olive, Electrical energy in kWh/ton olive, Fuel for heating in kg/ton olive and Defatted pomace in kg/ton olive.

Existing treatment methods of Zibar worldwide can be classified into four general categories:

1. Physical methods: Evaporation ponds (lagooning) and Classification by gravity
2. Biological methods: This treatment method must be efficient, allow for easy and economical operation, and consider the seasonality and the distribution of olive oil production. Therefore, a variety of biological methods (e.g. anaerobic digestion, Plant remediation, Co-composting of Zibar with Olive Stone Waste Residues and Detoxification by Nitrogen fixation (Bio-wheel method). Microorganisms for treatment of Zibar should be tested, and reviewed by many researchers to remove the dark coloration, reduce the organic load and remove phytotoxic compounds (Capasso et al. 1995).
3. Physicochemical methods: Membrane's technology and Wet oxidation (EHO method) and Phenolic compounds removal using ion exchange technology

4. Combined Chemical and biological methods: Fenton oxidation following by co-composting with pomace

5.1.1. EVAPORATION PONDS (LAGOONING)

Greece is one of the major olive oil producing countries. It has the same climatic conditions as Jordan. The usual treatment and disposal method for Zibar in Greece is the lagooning in evaporation ponds after neutralization with lime.

The treatment of Zibar adopted by Greece usually includes the following elements:

1. Contact reactor with addition of lime:
2. Transport system
3. Evaporation basin

The treatment steps that Zibar goes through are listed below:

1. The first step of this treatment is to neutralize Zibar by addition of lime, to a pH value at approximately 7 (2% CaO or 5 kg CaO/ton of olives).
2. The evaporation ponds are usually situated away from the mill and residential areas, because of problems of foul smell. During the production period (3-5 months) the ponds are filled whilst the evaporation process is ongoing till the ponds are emptied (8-9 months) and the leftover solid waste can be removed.
3. The remaining solid waste continue, however, to be toxic and additional treatment is necessary before the solids can gain commercial value e.g. as compost. The method's greatest advantage is its simplicity and low fixed investment and operational costs. Disadvantages of this method are: a) the need of large areas (1 m^2 per 2.5 m^3 of waste water), b) the lagoons have to be located at least 2km away from domestic areas, c) the threat of leakage of the wastewater through the soil and into the groundwater, d) the produced odors in the surrounding area.

5.1.2. CLASSIFICATION BY GRAVITY

This method is composed by a gravity settling concrete basin, which is divided in three sections with concrete partitions, an open soil trench, a concrete platform for the post handling of the settled sludge and a soil-plant filter the disposal of the excess supernatant from the storage lagoon. The gravity settling basin is followed by separate handling of the resulting waste fractions.

The simplicity and efficiency of the suggested waste management system, under real conditions are the central idea of that method.

In the basin, Zibar is separated in three fractions, the supernatant, the settled sludge and the oily floating layer. The supernatant has been stored and evaporated in an earthen lagoon and the sludge and oily layer in the second and first sections of the settling basin. An earthen trench and a concrete compost platform are also proposed to use for utilising the settled sludge. This classification of the different fractions is inversely proportional of the environmental problems created by this kind of waste. The most odorous and problematic fraction is the oily layer, which should be collected separately. It can be passed through the decanter to obtain its oily content or to be buried in a soil trench to be converted with the sludge in a soil-compost final product.

5.1.3. ANAEROBIC DIGESTION (AD)

Although methane is produced which could be used as fuel for electrical or thermal energy production as well as the original organic pollutants are reduced (about 70%), the resultant effluents are still too discoloured and polluted to be released into the environment. The treatment method is very complex and has problems with the suitability of its use in the treating of zibar as the large concentration of phenols and large chain fatty acids are toxic for the methanogens, which are the vital bacteria types for the function of the anaerobic treatment. This method couldn't be applied at the plant scale and more, due to the seasonal olive oil production; zibar must be co-treated with other wastewaters (dairy waste, piggery waste, etc.). The viability of this method is under consideration. The advantage of this method is the biogas production and the disadvantages are the high fixed and operation cost, the complicated system which makes it difficult to be applied in a single olive mill, the effluents and the sludge continue to be toxic and needs further treatment.

- Completely Mixed Anaerobic Digester

The completely mixed anaerobic digester is the basic anaerobic treatment system with an equal hydraulic retention time (HRT) and solids retention time (SRT) in the range of 15-40 days in order to provide sufficient retention time for both operation and process stability. Completely mixed anaerobic digesters without recycle are more suitable for wastes with high solids concentrations and a high volumetric loading rate is only obtained with quite concentrated waste streams with a biodegradable chemical oxygen demand (COD) content between 8000 and 50000 mg/L. Typical organic loading rate (OLR) for completely mixed anaerobic digester is between 1-5 kg COD/m^3.day

- Up-flow anaerobic sludge blanket reactor

It is widely applicable in relatively dilute municipal wastewater treatment and over 500 installations in a wide range of industrial wastewater treatment including food-processing, paper and chemical industries.

Influent flow distributed at the bottom of the UASB reactor travels in an up-flow mode through the sludge blanket and passes out around the edges of a funnel which provides a greater area for the effluent with the reduction in the up-flow velocity, enhancement in the solids retention in the reactor and efficiency in the solids separation from the outward flowing wastewater. Granules which naturally form after several weeks of the reactor operation consist primarily of a dense mixed population of bacteria that is responsible for the overall methane fermentation of substrates. Good settleability, low retention times, elimination of the packing material cost, high biomass concentrations (30000-80000 mg/L), excellent solids/liquid separation and operation at very high loading rates can be achieved by UASB systems.

The only limitation of this process is related to the wastewaters having high solid content which prevents the dense granular sludge development. Design OLR is typically in the range of 4 to 15 kg COD/m^3.day.

5.1.4. UTILIZING UP-FLOW ANAEROBIC SLUDGE BLANKET (UASB) REACTOR FOR TREATING ZIBAR – THE RSS PILOT AND RESEARCH PROJECT

A laboratory scale Up-flow Anaerobic Sludge Blanket (UASB) reactor performed by Subuh in 1999 proved that the removal efficiency of the soluble fraction of COD reached 76%. Different research checked types of reactors such as stirred-tank reactor, fluidized-bed reactor, and UASB reactor. UASB has showed a promising technique for anaerobic treatment of Zibar.

The objective of the pilot and research project conducted by the Royal Scientific Society (RSS) was to determine the characteristics of Zibar in Jordan, study Zibar impacts on surface and groundwater, and to study a treatment method using the Up-flow Anaerobic Sludge Blanket Reactor (UASB).

This type is a bottom feed, vertical flow and circular cross section (European type) with a diameter and height of 0.35 and 1.1 m respectively and was used for both research and community demonstration.

RSS with assistance from the IDRC of Canada and USAID launched two applied research projects; one of them additionally studied the socio-economic dimensions.

The RSS took Zibar samples from 22 olive mills and adopted standard methods for Zibar examination. The results of the characterization of Zibar were in accord with those presented in Section 3.4 above.

Based on the results of Zibar quality, the RSS studied the potential treatment options and concluded that the UASB reactor method was favored and seen most appropriate.

The UASB Reactor:

- It is a tank partly filled with anaerobic sludge which has good settling properties. The influent is fed into the bottom of the tank where it comes in contact with the sludge.
- UASB-type reactors and anaerobic filters are suitable for high volumetric pollution loads (5---15 kg COD=m3 day). COD removals of 80% and 60–65%, respectively.
- A high dilution ratio is required (1=8 and 1=5) that raises operational costs.
- Anaerobic filters require very little process control and 75% reduction of phenols.
- Requires the addition of alkali substances to neutralize pH and of substances that are sources of nitrogen such as urea or ammonia.
- The anaerobic microflora also shows limited efficiency in the removal of aromatics, particularly condensed tannins.
- Growth rates of anaerobic microorganisms are appreciably lower than those of aerobic ones and their metabolic degradation pathways require several different microbial populations in series which make process control and stability very delicate

The adopted treatment by RSS was based on the following:

1. A simple treatment method was selected due to the fact that the scheme should be applicable at large scale at individual olive mills or at a central treatment unit.
2. The effluent can be discharged to domestic WWTPs for post treatment so as to the keep the cost of specialized treatment of Zibar as low as possible.

Results of the research are as follows:

1. COD removal efficiency is 75%
2. Biogas analysis (CH4 is 79.6%, and CO2 is 17.5%)
3. This estimation was based on the following assumptions:
    - Zibar quantity of 200,000 m^3/season
    - COD of 117 kg/m^3
    - Anaerobic biodegradation of 1 kg COD yields 0.35 m^3 CH4
    - Treatment efficiency is 75%.
4. Drawbacks of the UASB are that it needs post treatment, the need for mixing with other types of industrial wastewater, and long start-up stage. Recommendations by RSS:
    - The construction of central treatment plants in the different areas (e.g. 9 central treatment plants)
    - The effluent of these plants is to be discharged in the existing domestic WWTPs for further treatment
    - The treated Zibar effluent will be reused in irrigation

5.1.5. PHYTOREMEDIATION

This treatment method is in essence based on using Zibar for irrigation and so benefiting from the natural biological cleaning processes and the breaking down the substances present in the Zibar that takes place when it is allowed to percolate through the soil. The use of this wastewater as a fluid-fertiliser improves the growth rate of crop by helping the soil develop microflora that are good at fixing nitrogen and improving the physicochemical characteristics of the soil that also improves the storage capacity of water and minerals.

There are some conditions applicable to this treatment method that must be considered before deciding if this method is suitable for Jordan or not. These conditions are that: a) the method can only function well once a soil analysis is carried out to determine the physical and chemical characteristics of the soil and b) the dosage is kept strictly to 30 m^3/ha/yr. To avoid phytotoxic effects of phenols and osmotic pressure changes, there should be one-month period prior to seeding where the wastewater is not used for irrigation purposes. Once seeding and growing starts again, the wastewater should not be used. Problems are therefore the rather strict observation of the rules and dosage limits. The type of soil that is suitable is a vital component to the success of this treatment.

Problems could occur because of the acidity of Zibar, but lime could be added to neutralize some of the organic acids present. It is in acidic soils where this could present the largest problems. But in these cases, a thorough investigation of the soil characteristics should prevent this.

Nevertheless, this method cannot be considered from an ecological and environmental point of view due to the potential contamination of groundwater and soil.

In terms of scale, this method is applicable to one mill and also to local/regional scale.

The advantages of this method are the simplicity and the low fixed and operational cost (about 5 cents/kg olive oil) excluding the sludge treatment cost and the proper management to prevent contamination of ground waters and the soil.

The disadvantages are the air emissions and odors especially in summer time, the risk of ground waters contamination. This method requires additional research and development before being used and is not in accord with relevant national legislations.

As a result, direct reuse of this wastewater in agriculture is limited by the phytotoxicity and antimicrobial effects due in particular to its high content in phenolic compounds, low pH and the presence of toxic fatty acids.

5.1.6. CO-COMPOSTING OF ZIBAR WITH OLIVE STONE WASTE RESIDUES

This method uses the olive stone waste residues as bulking material for composting of Zibar. In this method, the olive stone waste residues are mixed continuously with Zibar in a vessel-composting reactor under certain controlled temperature and moisture levels. In order to keep a stable moisture level and a balanced heat in the reactor, the method depends on feeding the Zibar at a certain rate to follow the need for moisture content and in the same time, feeding the olive stone waste residues at a certain rate to follow the need for carbon content.

These conditions help destroy the olive stone waste residues and turn it into a solid waste that after a 1-2 months maturity period can be transformed into a soil conditioner.

The advantages are that this method is an integrated method for Zibar management, the end products comply with national legislations, and produce a marketable by-product.

However, a major disadvantage of this method is the low rate of composting due to phenolic toxicities of the substrate. For this reason, the final ratio of two substrates (liquid wastes/solids residues) cannot be more than 2. Additionally, depending on the type of bioreactor, Zibar must be

stored for less or long time creating the same environmental problems of that of evaporation ponds, the pomace (Jift) could not replace the olive stone waste residues because of its high toxicity, else the final product could not be characterized as a biological fertilizer. Last but not least, the method is not simple so it is difficult to apply in a single olive mill.

5.1.7. BIO-WHEEL METHOD

This method is based on aerobic biological detoxification of Zibar using nitrogen fixing microorganisms whose activity fix molecular nitrogen. Many problems evolved when this method was installed at a full scale which does not encourage its implementation. For example, the effluent BOD was still too high and polyphenols could not be broken drown due to some undefined aggressive inhibition factors that interrupt the nitrogen fixation process and the degradation of phenolic compounds. This means that further treatment is still required and that the end product does not comply with national legislations.

5.1.8. MEMBRANES TECHNOLOGY AND WET OXIDATION (EHO METHOD)

This method is based on chemical oxidation of soluble organic pollutants using oxygen under high pressure. Even though the end product complies with the national legislations and the electric energy production, still, the method is not financially viable due to high investment and operation costs and also is a very technically complicated method that requires special technical capacity.

5.1.9. DETOXIFICATION USING FENTON OXIDATION REAGENTS FOLLOWED BY CO-COMPOSTING OF EFFLUENTS WITH POMACE

This method uses Fenton reagents (H2O2 + Fe+2) in order to attack the phenolic compounds found in Zibar. This detoxification of Zibar increases the anaerobic rate of biodegradation and the rate of aerobic degradation by about seven folds and five folds (respectively). Consequently, all biological treatment methods become more effective.

An integrated approach using Fenton reactions for detoxification of Zibar following a sludge-wastewater separation process, an anaerobic – aerobic treatment process and a composting process for the produced sludge can eliminate all disadvantages of the above mentioned biological and co-composting methods. The liquid end products comply with national legislations, the composting process is much more simple whereas the final product has much better fertility and soil conditioning quality. This method could be used either to 3-phase mills or 2-phase mills.

Also, this method can be split into two parts: the waste treatment unit and the marketable by-products (antioxidants and soil conditioner) production unit.

The first part could be applied at scale up to 3 local mills while the second part could be applied at region scale (the larger the better).

The advantages of this method are: It is an integrated method for Zibar management, end products comply with national legislations, it produces a marketable by-product, simple to install and to operate, and has low fixed and operational cost.

5.1.10. POTENTIAL VALORIZATION OF ZIBAR BY-PRODUCTS

Most the Zibar treatment methods rely on using a single process for treatment and using effluent for agriculture purposes.

Zibar has a high polyphenols (max 45-60 %), and high antioxidant properties. This method is based on extraction and purification of polyphenols from raw Zibar and from Zibar treatment by-products and subsequently easily treating the resulting wastewater up to complete re-use. The obtained polyphenols rich fraction can be applied in the cosmetic industry, the same as polyphenolic products obtained from other raw food processing by-products, such as tea leafs and grape seeds. According to the broad research, biophenols have demonstrated a high added value thanks to their positive actions in the prevention of tumors, and thus, in a pharmaceutical field. If further studies confirm that these molecules, if obtained at a very high purity rate, can be used as new products in medicines and as specific supplements, their economic advantages could be envisaged.

However, this is a just a research method and it is still not possible to know an exact market price of the biophenols recovered from Zibar and separated up to a high purity grade. The research predicts that the value of concentrates obtained from a small/medium size olive mill is about 70.000 € per year. This method is also expected to reduce Zibar treatment costs. Nevertheless, high investment and operation costs prevent this method from being used for Zibar treatment in olive oil producing countries and specifically in Jordan.

5.2. EVOLUTION OF COUNTRIES EXPERIENCES

Many of the oil producing countries have water scarcity problems (e.g. Cyprus, Jordan, Greece, Southern Italy, Southern Spain...etc), which justifies the need to save the water from the olive oil milling process.

1. **Spain:** Since 1980s, the disposal of Zibar water in wadis was prohibited, and sohundreds of evaporation ponds were constructed which improved the water quality but raised annoyances in ambient air quality because of odor problems. Nowadays, almost all olive mills in Spain are 2-phased and so produce minimal amounts of Zibar. The already existing evaporation ponds suffice to handle the remaining amounts of produced Zibar. Also, most of the mills

started to use water recycling which means that all evaporation ponds will eventually be close down.

2. **Italy:** around 6000 olive mill sin Italy are operating on the traditional oil extraction method. Italy is the only country that has specific legislations for the disposal, and/or recycling of olive processing wastes (e.g. land spreading of wastes arising from olive processing is specifically regulated under Law No. 574 of 11/11/1996. However, enforcement authorities face issues of implementation and inspection since they do not know the exact dates and places of spreading. The typical process of Zibar management in Italy is land spreading, which is not an environmentally acceptable solution to be considered. Meaning, that the presence if legislations is insufficient in the case of Italy. Proper treatment technologies and enforcement mechanisms must be mainstreamed within the legislations in order to ensure compliance and ease of implementation.
3. **Greece:** 70% of around 3000 olive mills in Greece are 3-phased and a very small number uses 2-phased mills and that is due to the issues with drying the Jift. There are no specific legislations for management of wastes from olive mills but olive oil producing mills have their own environmental requirements and build on gained local experience and research projects to encourage the use of proper management and treatment options. On the other hand, Greece authorities do not issue an olive mill operation permit without providing a plan with measures to treat the olive mill waste. Authorities planned to issue a new licensing requirement and that is to have the Zibar treated with lime before disposal in the natural recipients. But this was not enforced. Nowadays, many of the olive mills dispose their Zibar in mud ponds.

   All the research done in Greece concluded that there is no single technical solution that can ensure a satisfactory level of treatment efficiency whose application cost will be within the economic means of each individual olive-mill owner. The research also concluded that given the distribution of mills evaporation ponds are the best options to be used for treatment and disposal of Zibar, optionally after neutralizing with lime.
4. **Tunisia:** the common way to deal with Zibar in Tunisia is to convey it all from the mills to a central point to be discharged into a purpose built lined lagoon where the volumes are reduced by evaporation which is found to be a very reasonable way for containing the problem. Tunisia uses Zibar for restricted irrigation.

5.3. Selection of the Technologies and Methods of Zibar Treatment

The brief description of current practices for Zibar management in example olive oil producing countries provided in Section 5.2, leads to conclude that a good amount of research has been done

regarding olive mill wastewater treatment methods. However, none of the proposed methods can be considered as a best available method in terms of its effectiveness, and its environmental and economic impact.

In another analysis done by Zagklis et.al in 2013 showed that the most effective processes in terms of organics reduction are membrane filtration, electrolysis, supercritical water oxidation and photo-Fenton. Lower environmental impact was found with anaerobic digestion, while the lowest cost category involves evaporation ponds (lagooning), and biocomposting, especially if the byproducts were exploited (e.g. biocompost).

After assessment of all the alternative options for Zibar treatment, "Evaporation Ponds (Lagooning)" could be considered as the most appropriate option for Zibar treatment in Jordan. This has been confirmed by the latest study funded by the European and Investment Bank (EIB) as part of the Horizon 2020 Program; 'Integrated Solid Waste Management in Al-Ekaider – Jordan' as well as the RIAL II Project team. The reasons that lead to this conclusion are the following:

1. The most common and cheapest treatment option identified and widely used in Greece, France, Tunisia, and Cyprus
2. Other than the cost for the excavation and earth works, this option has low capital, operation, and maintenance costs.
3. This option is not high technology and requires less operation and maintenance works.
4. Does not require highly experienced staff to treat the Zibar.
5. The olive mill owners already showed unwillingness to pay for additional Zibar dumping fees, so, it would be preferable to select the treatment method with the least amount of investment.
6. The only by-product that occurs from the Zibar evaporation method is dry sludge that can be disposed in the closet solid waste landfill.

Example criteria for site selection of the evaporation ponds:

1. Distance from community
2. Availability of land
3. Proximity from olive mills
4. Environmental factors such as water resources and biodiversity…etc.
5. Location could be within an existing WWTP or within an existing landfill)

Further details on the preferred and recommended Zibar treatment method will be provided in Section 6.

6. RECOMMENDATIONS FOR JORDAN

The olive mill owners and the authorities in Jordan face many challenges in the operation of the mill and in the management of Zibar. Many issues have come together to cause the improper management practices of Zibar reported in Section 1.1 of this report. Some of these issues are the following: the seasonal nature of olive oil production, the geographic dispersion of mills, weak enforcement, absence of legislations, low level of awareness amongst olive mill owners to the environmental and health impacts of Zibar, financial limitations for cost effective treatment, etc.

The solution to these problems needs the collaboration of all entities involved and the harmonizing of their efforts. Holistic planning is needed to implement a master plan for Zibar management chain and this will be done by linking upstream with downstream operations through planning, research, regulatory, institutional, financial, and technical means.

The text below will study the potential solutions to be implemented upstream and downstream. An integration of these solutions, with political support, will help solve issues with Zibar management is Jordan.

The rule of law plays an important role in translating the plans into reality in order to eventually reach compliance. Regardless of the chosen technology, it is and has been always the legislations that frame and guide our way of conduct and define our quality objectives. Hence, this Section will start with the plans that will help mainstream Zibar management into the environmental process and policies and bring in suggestions for legal and institutional strengthening. The technology selection itself has been discussed in Section 5 and will be summarized here in this Section. The tariffs are also central to several decisions, most importantly, the investments in technology solutions for the treatment of Zibar.

6.1. Policy, Legal, and Institutional Recommendations

In order to mainstream Zibar management into the environmental process and policies, it is essential to adopt regional/international best practices in olive producing countries and introduce necessary measures for institutional strengthening and internal capacity building so that the investment and efforts made to improve the services can be sustained. Institutional strengthening can be done by

adequately specifying responsibilities and interrelated mandates of different entities in relation to Zibar management in Jordan and specifying an entity to lead and plan Zibar management.

Based on the legal and institutional review exercise in this section, and as is clear, some issues are regulatory in nature and require modifying active laws and regulation, such as introducing the new policy and legislation that governs Zibar management, clearly specify responsibilities, introduce new tariffs applicable for a new Zibar treatment plant that are set based on adequate technical and financial examinations (it should tackle issues such as policy, the institutional and legal framework, investment planning, financial management, and cost recovery), and of course all these require monitoring and enforcement. These are prerequisites for any development activities that can be implemented in Jordan.

A comprehensive assessment should evaluate the options for a complete institutional, regulatory and policy reform in relation to Zibar. According to the mandate described in Table 8, the most suitable entity to undertake the Zibar management and planning mandate is the Ministry of Environment since they are the core entity responsible for industrial wastewater. In accordance to such recommendation, the following must be addressed:

1. **Policy aspects:**

- Development of a clear policy statement for MoEnv in consultation with different stakeholders (MOA, MOH, MWI/WAJ, MOMA/GAM, Environmental Rangers, and the Jordanian olive mill owners and olive oil producers union). The policy statement should:

  - Outline the overall vision and mission for Zibar management, strategic objectives, and necessary long, short, and immediate actions necessary for restructuring and streamlining the operations of Zibar management and achieve set targets and objectives.

  - Clarify the roles and responsibilities of all organizations involved in the sector along with their authority levels. Responsibilities for each entity should be clearly defined and mechanisms to regulate, monitor, and evaluate the performance of the management chain designed.

  - After this framework is defined, MoEnv should work in collaboration with other entities to define the necessary legislations (standards, instructions, guidelines…etc) that should be created or modified.

2. **Inter Organizational relations:**

- A Communication scheme and protocol should be formulated that will govern the inter-organisational relations between MoEnv as the entity responsible for planning and monitoring Zibar management practices and other regulatory entities MOA (licensing),

MWI/WAJ (implementation), MOH (monitoring), MOMA/GAM (implementation and monitoring), and other organizations in order to ensure an effective communication and responsiveness process and better efficiency in handling the different issues.

3. **Sector Standards and Guidelines:**

- MoEnv should be responsible for formulating various sector documents that will help in guiding the operations of Zibar, and enable effective regulation, development, management, and operation.
- The following are an example of the typical sector standards and guidelines pertaining to Zibar management that are needed on a priority basis: Zibar management standards, Instructions for enforcement, Operational guidelines and standards for collection, intermediate storage, transport and disposal, and treatment of Zibar; construction and operational codes for Zibar treatment plant, gate fees and tariffs for the Zibar treatment plant, etc.

4. **Regulatory Framework**

- After defining the institutional framework, the necessary regulatory framework should be proposed to ensure the presence of an enabling legal environment necessary for a proper Zibar management scheme to work effectively. In line with the strategies recommended to re-engineer the institutional framework to remove ambiguity from the current setup, the regulatory framework will require formulation of new instructions and specifications.
- These should at least address the following:
  - Assigning MoEnv to have full authority over Zibar management in Jordan
  - Define/clarify the mandate and roles of the various governmental agencies including MOA, MOH, MWI/WAJ, and MoMA/GAM to ensure proper understanding of responsibilities and have accountability mechanisms in place.

5. **Implementation scheme:**

- The MoEnv too must commit to their own legislations which means that they should:
  - Work together with MWI/WAJ or/& MOMA to plan establishing a proper final disposal/treatment scheme for Zibar and together with these potential implementation entities find suitable funding mechanisms to ensure sustainability.
- MoEnv must work on enhancing their inspection and enforcement and collaborate with other national efforts to protect the environment by raising awareness of olive mill owners & tankers regarding the negative environmental impacts of illegal Zibar disposal.
- MoEnv and MOA can help promote best practices in the olive mills by applying regulations, using economic instruments, providing support measures, obtaining external assistance,

channeling research to help guide the management processes within olive mills, raising their awareness, …etc.

- Find solutions for limiting factors that are seen as obstacles by olive mills (Lack of knowledge, complexity and capital and operation costs for efficient treatment options)
- The olive mills do not have the financial ability to implement investments that help reduce Zibar generation in their mills. The MOA and MoEnv in collaboration with donor agencies and with the Jordanian olive mill owners and olive oil producers union, can investigate ways to assist the olive mills in implementing such improvements (e.g. revolving funds, microfinance mechanisms …etc. Loans could be given to olive mills to implement the improvements and paid back over installments. At the national level, the improvement interventions could be phased and implemented over a number of years.

6.2. UPSTREAM SOLUTIONS

'Upstream solutions' here refers to the intervention and enhancement measures to be taken within the grounds and borders of the olive mills. Additionally, it refers to the transportation of the Zibar by tankers to the designated disposal site.

6.2.1. THE OLIVE MILLS

Even though this solution is not envisaged to take place at anytime in the near future due to various limitations, however, it is still being included in this section in order to demonstrate its positive contribution in solving the issues of Zibar management.

Currently, most of the olive mills in Jordan are 3-phased and so greater amounts of Zibar are produced. In the 'Cleaner Production (CP) in Olive Oil Industry in Jordan' report of 2007, the following improvement interventions were recommended for source reduction to establish an olive mill with less amounts of Zibar and so reduce the burden on the mills and the authorities. These are as follows:

1. Technology modification Options

- Factors that influence the Zibar Characteristics are: Seasonal and climatic conditions (*Cannot be controlled by olive mills),* Olive fruit composition *(Cannot be controlled by olive mills);* Harvesting time and technique *(Can and are being controlled, but does the criteria used for deciding the harvesting time take the impact of timing on Zibar characteristics?),* Storage time *(Can be controlled by the olive mills),* and Olive oil extraction technique *(Can be controlled by the olive mills).* Additionally, the % of Residual oil in Zibar is a factor of decanting system used -natural vs. centrifuge *(Can be controlled by the olive mills).*

- Exchange between the Dual Phase and the Triple Phase systems
- Another option is the two and a half oil decanter
- De-stoning Olives before Malaxation: according to the 2007 study, an average of 50% reduction in added water and a consequent 50% reduction in generated wastewater is expected. Added to that, an expected 1.5 X increase in the oil mill capacity and 50% reduction of Jift due to destining of olives. Also, stones can be used as animal feed or add to soil conditioner.

2. Water Conservation Options (Washing water recycling)
3. Housekeeping practices:

- Proper and faster cultivation, packaging, transportation, and storage of olives.
- Regular preventive maintenance of equipment at the olive press.
- Proper containment of Zibar to prevent any leakage to any parts of the environment.
- Proper collection of refuse and transportation to designated landfill.

4. Technology Replacement in the olive mills:

- Shift to dual phase technology.

Benefits:

I. Reduction of around 36,000 t/year of water consumption for 45,000 t/year of processed olives
II. 60% reduction of Zibar quantities
III. Savings in Zibar treatment costs
IV. Less labor

The 2007 study estimated investment costs as follows:

I. Total cost for converting the entire three phase traditional mills as investment costs figure to be USD 16-20 million
II. Each 2 phase decanter cost around USD 122,000
III. Additional cost for wet pomace drying in dryer kilns with small capacity could cost USD 135,000 to USD 169,000 with additional investment cost by no less than USD 27,000 to USD 31,000.

- Replacement of 3 phased decanters with 2.5 decanters

Benefits:

I. No major modifications needed
II. Reduce water consumption need by 35-40% compared to its descendant three phase decanter
III. Reduction in Zibar generation

The 2007 study estimated investment costs as follows:

I. USD 6.7 million for replacing all three phase decanters in Jordan

- Install water meters and water saving equipment

Benefits:

II. Reduction in excessive water consumption
III. Reduction in Zibar quantities

The 2007 study estimated investment costs as follows:

I. The cost of a fully integrated water monitoring and saving system, depending on each mill's case by case, is estimated to be between USD 250 and 350 per mill.

II. possible water savings amounting to 100,000 m3/year and an average cost of water of 150 cents per m3, total annual savings in water could amount to about USD 150,000

III. Payback period of the investment is on average 1.7 years

- Pre-treatment of Zibar in the onsite storage tanks by lime+aeration+mixing

Benefits:

I. Minimizing Zibar pollution load

II. 100% removal of o-diphenols which are highly phtotoxic

III. Removal of fatty compounds which *allows evaporation more easily – no more think film of top layer*

IV. 55% reduction in COD

V. 25% reduction in BOD

VI. 60% nitrogen reduction

VII. 30% total solids removal

VIII. 70% color removal

IX. pH neutralization

X. Reduction in sludge formation

XI. Future savings in Zibar treatment costs

XII. Removal of nutrients inhibiting the use of water as fertilizer.

The 2007 study estimated investment costs as follows:

I. Pre-treatment investment cost: Cost of lime = 15 USD/m3, Cost of Dosing system approximately USD 200, Cost of aeration diffuser system approximately USD 500, Concrete holding tank with 2 days capacity approximately 200 USD/m3 (already present in the olive mills)

II. Total cost of pre-treatment with lime on national level of all annual generated Zibar is approximately USD 4.2 million per year.

III. Capital cost of installing lime dosing system and aeration system for all mills is estimated to be around USD 321,000.

Currently, there is no treatment for the Zibar in the mill. Simply because olive mills in Jordan are small to medium and do not have the funds and the technical capacity needed to construct a proper Zibar treatment unit onsite. The treatment method will have to be very simple and cheap if mills were to build them onsite.

The role played by the MOA is generally efficient, some strengthening of their institutional capacity is needed in order to help the olive mill owners and raise their awareness to best management practices onsite and their payback period as listed in the potential improvement interventions above.

The olive mills do not have the financial ability to implement the investments listed above. The MOA and MoEnv in collaboration with donor agencies and with the Jordanian olive mill owners and olive oil producers union, should investigate ways to assist the olive mills in implementing such improvements (e.g. revolving funds, microfinance mechanisms etc. Loans could be given to olive mills to implement the improvements and paid back over installments. At the national level, the improvement interventions could be phased and implemented over a number of years.

6.2.2. THE TRANSPORTATION TANKERS

Olive mills need to have their storage tanks emptied nearly at a daily basis. They have an agreement with transportation tankers to collect the Zibar and dispose it in the designated landfill. The setup linked with the operational license agreed between MOA, the Jordanian olive mill owners and olive oil producers union, and the olive mills seems to be efficient in the northern governorates. The mills are asked by law to have documentation of the amounts of their generated Zibar and the scheme implemented to transport their Zibar to the designated landfill. The mills use a manifest system implemented in agreement with the Irbid JSC in order to ensure that all amounts of generated Zibar are disposed in Ekaider dumpsite. The transportation tankers are asked to bring back the copies of the manifest signed by the Ekaider dumpsite with the amounts of disposed Zibar and the olive mill ensures no discrepancy between the amounts of Zibar collected by the tanker and those disposed in Ekaider. Otherwise, the mill does not pay the tanker for the transportation fees. In the same time, if the olive mill does not follow this procedure and provide evidence to MOA and the Jordanian olive mill owners and olive oil producers union, then they cannot get their operation license renewed.

This is an efficient management setup that if institutionalized and mainstreamed within the management practices for all mills in Jordan, would prove to be a reasonable scheme to ensure no random disposal of Zibar. Together with sufficient monitoring and enforcement, both will not only prohibit illegal dumping of Zibar by tankers, but will also induce mills to not look the other way while they implicitly assume that tankers dispose of their Zibar in wadis and sewers.

Moreover, the MoEnv with support from the Environmental Rangers should fully undertake their responsibilities to ensure compliance by olive mills and transportation tankers and any entity/tanker found not complying with the legislations should be penalized. They should also focus on increasing the level of awareness amongst olive mill owners and operators and also as included in the preceding

section, collaborate with donor agencies and the Jordanian olive mill owners and olive oil producers union to find a financial support system to the mills to enable compliance.

6.3. DOWNSTREAM SOLUTIONS

According to Section 5.3, most treatment technologies require high investment costs and a high level of technical capacity. Hence, even though this creates a burden of transportation costs, but a centralized treatment plant is considered more suitable to treat Zibar produced by olive mills.

As already established, olive mills generally do not have the sufficient financial capacity to implement treatment schemes upstream. Section 6.2.1 above proposed that the MOA and MoEnv in collaboration with donor agencies and with the Jordanian olive mill owners and olive oil producers union, investigate ways to assist the olive mills in implementing improvements onsite that will help in reducing the amounts of Zibar generated from each mill and also in enhancing the quality of generated Zibar. At the end of the day, it is not the objective of such enhancement to corner the olive mills to commit to treatment requirements that they cannot implement and eventually force them to close due to their inability to treat their Zibar properly.

6.3.1. TECHNOLOGY SOLUTIONS

As discussed in Section 5, many methods and technologies for treatment of Zibar were studied and investigated in olive oil producing countries, but none of the proposed methods can be considered as a best available method in terms of its effectiveness, and its environmental and economic impact. It is concluded in different countries that the "Evaporation Ponds (Lagooning)" could be considered as the most appropriate option for Zibar treatment in Jordan. It is even already used in other countries (e.g. Greece, Italy, Tunisia...etc).

The following briefly presents a solution for Zibar treatment in Jordan and uses findings of the European and Investment Bank (EIB) as part of the Horizon 2020 Program; 'Integrated Solid Waste Management in Al-Ekaider – Jordan' proposed the following scheme for Zibar treatment in Ekaider:

1. Parameters affecting Zibar treatment are the following:

- Olive-oil mills: Mill capacity (max or working capacity) (tn/h); Olive quantities processed/worked (tn/yr); and Olive-oil produced (tn/yr).
- Solid residues: Jift quantity (tn/yr or tn/tn of olive-oil); Moisture (%); Nitrogen, potassium, olive-oil residues, stone and fiber content (% d.w.); Jift oil extraction, used for compost, animal feed, spreading on soil, burning as fuel and stones burning (% of total solid residue).
- Wastewater (Zibar): Wastewater quantity (m^3/yr or m^3/tn of olive-oil); Zibar composition (BOD5, COD, phenols /poliphenols N, P, K, TS), pH, oil content (%), organic matter and mineral matter (% d.w.), electrical conductivity (dS/m), lipids (mg/l); % of Zibar to purification, to spread on cultivated soil, to compost; and Energy and water consumption, e.g. washing water (m^3/tn of olive-oil), process water (m^3/tn of olive-oil), electrical energy (kWh/tn olive-oil), fuel for heating (kg/tn olive-oil) and defatted pomace (kg/tn olive-oil).

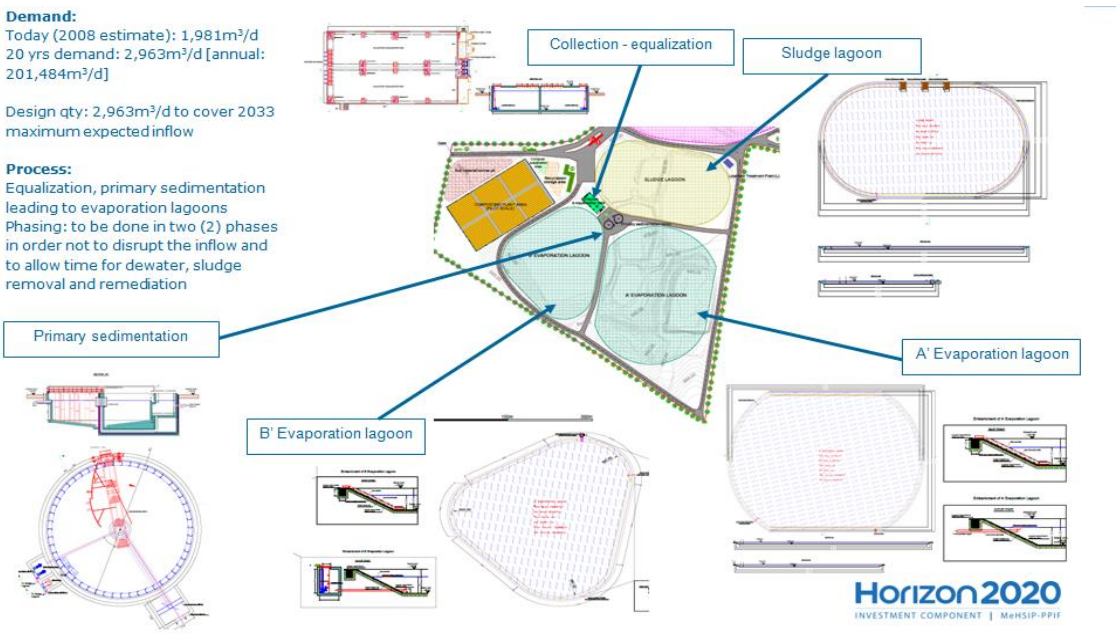
2. Zibar generation is only seasonal (85 days between mid October till mid of January) and hence, the design flow-rate should be based on the flow during peak season. According to MOA and Ekaider landfill, the duration of the season is 85 days. The maximum daily Zibar amounts received at Ekaider dumpsite is 1,381 m^3/d but reported by MOA to be 1,750 m3/day. So the annual design flow to be used is 165,000 (with contingency) for the Zibar generated by the olive mills in the northern governorate.
3. The study for the Horizon 2020 Program projected the amounts of Zibar to be received at Ekaider up to the year 2033 based on 'Virgin olive-oil production in Jordan, 1961-2010 (raw data source: FAOSTAT, 2010)' and also on the 2008-2010 values provided by RIAL II project in 2011. Accordingly, they projected the 1,381 m3/day in 2008 to become 2,963 m3/day in 2033. However, the olives and olive oil production in Jordan has not been increasing as such due to different reasons (e.g. scant water resources, reduction in amounts of rainfall, climate change impacts, soil fertility…etc). The forecasting of Zibar generation should be studied in further details before finalizing the treatment plant designs.
4. As per the Horizon 2020 Program, the quality data for the Zibar Treatment Plant (ZTP) Design are as follows:

- BOD5 (mg/l) 72,500; COD (mg/l) 140,000, TSS (mg/l) 15,000, and Phenolic compounds (mg/l) 200,000 (based on measurements of Zibar characteristics in Ekaider carried out by RIALL II).

5. ZTP is proposed by Horizon 2020 to be as follows:

- A combination of evaporation ponds with solids removal in sedimentation tanks and sludge stabilization by addition of lime. Lime addition in Zibar sludge does not cause any problems to the sludge's composting process if appropriate dosing is done.

- The phases of the plant are the following: Tanker receiving station; Collection / equalization tank; Constant flow pumping station; Chemical dosing with lime; Sedimentation tanks; Zibar sludge removal; Oil – grease removal; Oil separation with centrifugal system; Distribution chamber; Two stage lined evaporation lagoons; Sludge dewatering lagoon; Composting of dewatered Zibar sludge; and Recirculation of water in the compost unit. A technical description and conceptual design has been provided in the October 2012 Feasibility Study Integrated Solid Waste Management in Al-Ekaider' submitted to the Ministry of Municipal Affairs and to the WAJ representative member of the committee for review and comments.
- The minimum area proposed for the evaporation lagoons is 58,055 m2. However, this area should be revisited since the calculations were based on 68 days season and not 85. According to the calculations all Zibar will have evaporated before the new production period starts. Some suspended solids remains in the Zibar from the sedimentation tanks. These solids will sediment at the bottom of evaporation lagoons. Every 5-6 years, sludge will need to be removed from the evaporation lagoons (manually, due to the geosynthetic nature of the underlying membrane) and sent to the sludge lagoon.
- Layout and plan for the ZTP design (further detailed drawings are provided by the Horizon 2020 study):



6.3.2. TARIFF SETTING AND PRICING

Based on the findings of the feasibility study as part of the Horizon 2020 Program, the following tariff implications are concluded:

1. Investment cost (CAPEX) was estimated to be 5,138,500 € (6,948,285 USD).

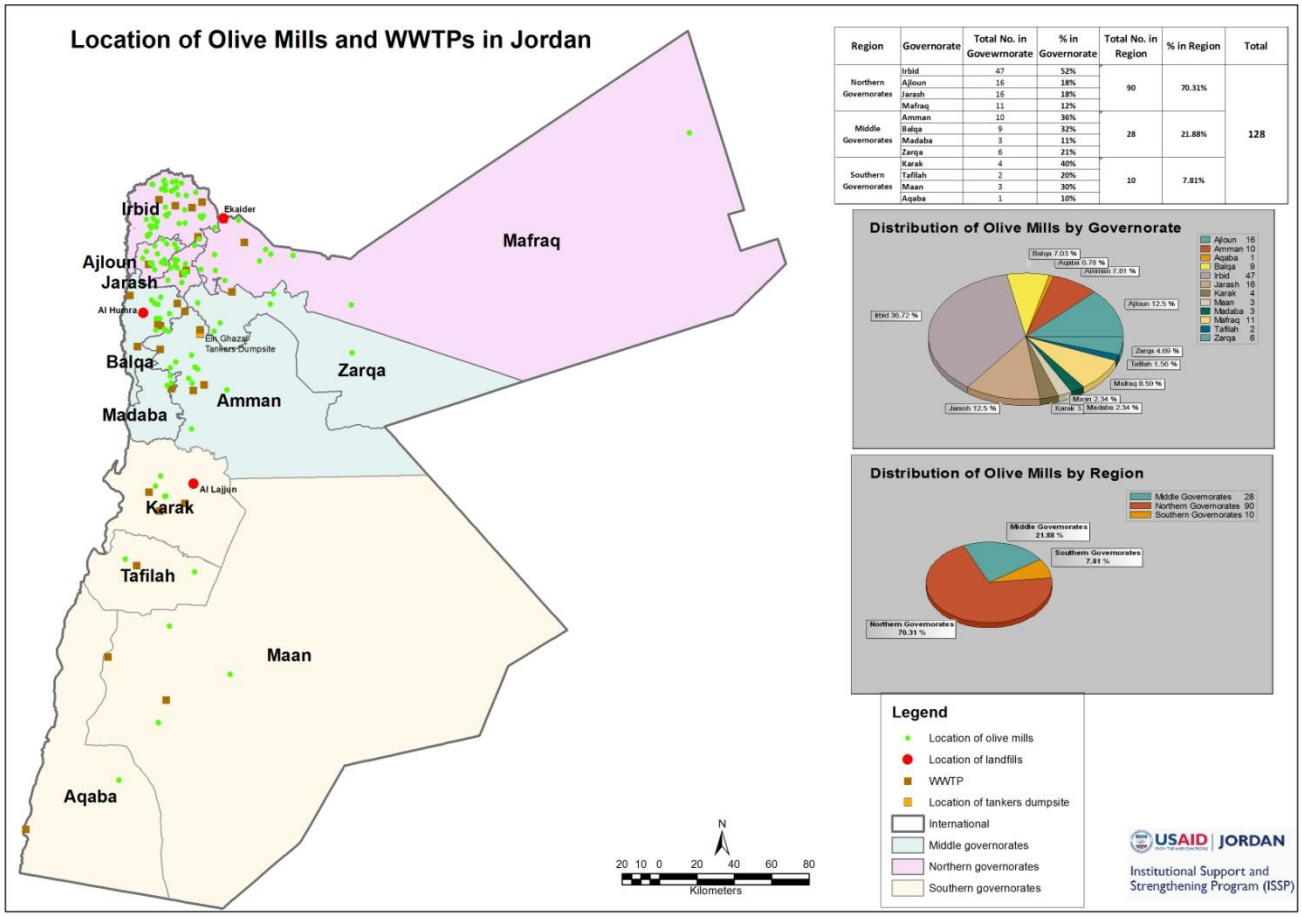
2. Yearly operational cost (OPEX) for ZTP (chemical and materials, and the personnel cost) for the first 5 years is estimated to be around 250,000 € (338,000 USD) and 355,000 € (480,031 USD) in the year 13.
3. Zibar from olive mills will be treated in the ZTP and disposed in the new lined ponds. The fee paid for Zibar disposal by mill operators is currently 330 JOD/production line/season. There is no link with actual quantities of zibar brought to Al-Ekaider. To match the zibar production estimates in m3/year, the current effective tariff has been interpreted by the Horizon 2020 study to 0.22 JOD (0.31 USD) per m3, based on an estimated 1,500 m3 average zibar production per production line per season (which is similar to the calculations done in Section 3.6.4).
4. If the ZTP was implemented, there is only one source of revenue and that is the Zibar disposal fees.
5. Based on the above capex and opex costs vs. the current effective zibar fees, the Horizon 2020 concluded that the revenue growth rates are declining over the project horizon and that revenue growth ranges from 1.3% to 1.5%, which is considered a weak growth rate. The Horizon 2020 found that the ZTP will never be able to cover its OPEX at the existing tariff over the study period (13 years). The earnings before interest, tax, depreciation and amortization calculations showed a margin value of -4% in year 1, -17% in year 5, and -49% in year 13.
6. The amount of funding required for developing and operating the project over the 13 years of the project period stands at € 6.58 million (8.9 million USD).
7. The results from the Net Present Value and Internal Rate of Return estimations were negative and pointed towards the rejection of the project from a financial point of view. The ZTP was found to be not financially valuable investment. This implies the need to find alternatives to fund the deficit in cost, both operational and capital.

8. The Horizon 2020 feasibility study found that one of the possible options is to increase the tipping fee of the Zibar disposal in order to cover the plant cost. In the case of a full cost coverage (CAPEX and OPEX), the fee has to be increased by around 250% to 300% by year 13 in order to achieve a viable financial investment (1.35 USD/m3 up from the current 0.31 USD/m3). Such scenario of fee increase could be difficult to impose; therefore if the tariff cannot be increased then it was suggested that the CAPEX should be covered by funds allocated by the responsible authorities.
9. Or to put it in other words, the fees per production line would have to be increased to JOD 1,320 from JOD 330. This is a sizeable increase in the fees that will almost certainly be opposed by the olive mill operators.
10. It is suggested that the government could contribute to the ZTP development CAPEX and increase gradually the tipping fee to cover the OPEX. If the government paid the full ZTP CAPEX cost, then the tariff to cover the OPEX would need to be increased to 409 JOD/production line.
11. The increase in tipping fees from 330 JD/production line/season to 409 JOD/production line/season could be bargained with the olive mill owners but defiantly not the 1,320 JOD/production line/season. If the latter was implemented, olive mills would close down their mills and stop the work or the tariff increase would be reflected on the farmers who cannot take in such financial load.
12. It is also suggested that tariffs be quantity based, rather that fee per production line. That would be more equitable to mills, as they would pay for what they produce, and avoid the possibility of mills cross-subsidizing others due to differences in production line output.

6.3.3. POTENTIAL LOCATION FOR THE ZIBAR TREATMENT PLANT

As already described in different parts of this report, around 70% of the 128 olive mills in Jordan are located in the northern governorates, around 21% in the middle, and around 7% in the southern governorates.

This would mean that in order to fit the various mills in terms of production size, and distance from treatment plants, different evaporation ponds will have to be established for the different regions in Jordan (i.e. North, middle, and south). The evaporation ponds can be established as part of an already existing dumpsite or WWTP, depending on the geographical location, technical suitability, land suitability, available land…etc. Based on the location of dumpsites and WWTPs in Jordan in comparison to geographical distribution of olive mills in Jordan (Figure 13), a strategic planning exercise can be done to select potential locations to serve the north, middle, and south regions.



Region	Governorate	Total No. in Govewrnorate	% in Governorate	Total No. in Region	% in Region	Total
Northern Governorates	Irbid	47	52%	90	70.31%	128
	Ajloun	16	18%			
	Jarash	16	18%			
	Mafraq	11	12%			
Middle Governorates	Amman	10	36%	28	21.88%	
	Balqa	9	32%			
	Madaba	3	11%			
	Zarqa	6	21%			
Southern Governorates	Karak	4	40%	10	7.81%	
	Tafilah	2	20%			
	Maan	3	30%			
	Aqaba	1	10%			

Figure 13: Spatial distribution of olive mills, dumpsites, and WWTPs in Jordan

6.4. Summary of Recommendations for Jordan

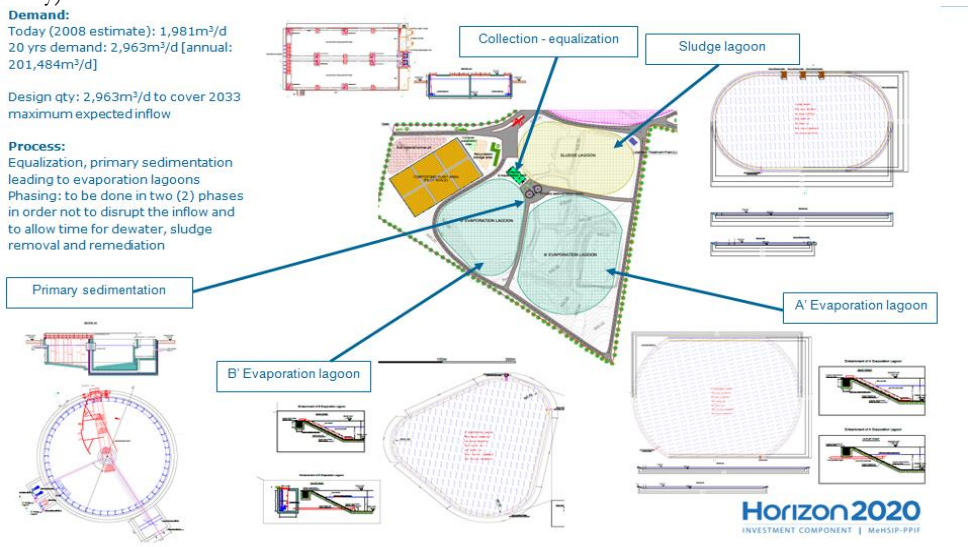
The solution to the Zibar problems needs the collaboration of all entities involved and the harmonizing of their efforts. Holistic planning is needed to implement a master plan for Zibar management and this will be done by linking upstream with downstream operations through planning, research, regulatory, institutional, financial, and technical means. Table 9 below presents the potential improvement recommendations to be applied upstream and downstream of the management chain. In conclusion, the solution of the Zibar management issues in Jordan requires a trilogy of suitable legislations, proper inspection and enforcement, and last but not least, proper disposal and treatment facilities spatially distributed within the three regions of the country. An integration of these solutions, with political support, will help solve issues with Zibar management in Jordan.

Table 9: Improvement Recommendations for Zibar management in Jordan

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
Upstream	**Policy and Institutional**	• Specify responsibilities and interrelated mandates of different entities and the entity to lead and plan Zibar management • Assigning MoEnv to have full authority over Zibar management in Jordan (the core entity responsible for industrial wastewater) • MoEnv should in collaboration with other entities introduce a new Zibar management policy, action plan, and proper legislations • MoEnv should formulate an inter-organisational communication scheme and protocol to facilitate communication between agencies • Adopt/customize regional/international best practices, policies, and legislations in olive oil producing countries • MoEnv should prepare the necessary standards, instructions, guidelines in relation to Zibar management, characteristics, transportation, handling, treatment, disposal…etc. • Introduce necessary measures for institutional strengthening and internal capacity building to ensure sustainability • MoEnv should formulate various documents that will help guide the operations of Zibar, and enable effective regulation, monitoring, development, management, and operation. • MoEnv in collaboration with the Environmental Rangers should undertake sufficient monitoring and inspection to ensure enforcement and compliance	• Capacity buildings for MoEnv and Environmental Rangers and one representative from each line ministries: 150,000 USD/training session (10 trainees in each governorate for one week in Jordan) • Technical Assistance to MoEnv to formulate policy, action plan, guiding manuals, instructions, guidelines…etc: 110,000 USD for an international consultant working full time for 3 months

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
		• MoEnv should work together with MWI/WAJ or/& MOMA to plan establishing a proper final disposal/treatment scheme for Zibar and together with these potential implementation entities find suitable funding mechanisms to ensure sustainability. • MoEnv should work on raising awareness of olive mill owners & tankers regarding the negative environmental impacts of illegal Zibar disposal. • MOA to complete its successful inspection and licensing process and learn by experience ways to strengthen the process. They should ensure proper maintenance of Zibar tanks before start of the season in the most efficient ways possible to ensure proper operation during the season. • MoEnv, MOA, in collaboration with other entities should develop a manifest system that tracks Zibar from generation in the olive mill to final disposal in the treatment plant. The tracking system should ensure no discrepancy in the amounts of Zibar throughout the chain. Compliance is measured through different indicators including inspection and the manifest. Operational Licensing should be granted conditional the manifest records throughout the season. Noncompliant mills and transportation tankers should be penalized • MoEnv and MOA can help promote best practices in the olive mills by applying proper regulations, using economic instruments, providing support measures, obtaining external assistance, channeling research to help guide the management processes within olive mills, raising their awareness, implementing finance mechanisms (revolving funds, microfinance…etc).	• Logistical support to MoEnv to undertake inspection during the season: 250,000 USD for one car purchase for each governorate and 26,000 USD operational costs (Fuel and maintenance) for these cars per season • Support to MOA for inspection in olive mills: 7000 USD/season • Incentives to MoEnv/Rangers inspectors: 30,000 USD/season (3 inspectors in each governorate)
Downstream	**Institutional**	• MoEnv in cooperation with WAJ &/or MOMA shall collaborate to select the most suitable option for Zibar treatment, select suitable locations for the Zibar treatment plant for each of the three regions (criteria for site selection: distance from community, availability of land, closeness to all mills, environmental factors such as water resources and biodiversity…etc. Location could be within an existing WWTP or within an existing landfill) • MoEnv in cooperation with WAJ &/or MOMA shall discuss the following: examine ways for funding, possibility for public private partnerships (e.g. Jordanian olive mill owners and olive oil producers union can invest in the treatment plant and charge the olive mills for disposing and treating their Zibar in the evaporation pond), best management scheme of the treatment plant, capacity building of staff, formulating the operational manual of the plant, …etc). • MoEnv to undertake regular monitoring and check of the treatment efficiency of the Zibar, the quality of the effluent, and protection of environment. They should also review the monthly reports prepared by WAJ/MOMA for the Zibar treatment plant and ensure its compliance • Capacity building of Zibar treatment plant staff (WAJ &/or MOMA) • Zibar treatment plants developers to apply for Environmental permitting (location permit, EIA)	• Capacity building of Zibar treatment plant staff (WAJ &/or MOMA): 25,000 USD/year • Technical assistance to WAJ &/or MOMA: 800,000 USD for design, feasibility study, institutional study, procurement, and tendering • MoEnv regular monitoring and monthly follow-up: 7000

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
		• Capacity and facilities to implement the environmental monitoring program	USD/year • Location permit: 600 USD for three locations • EIA: 100,000 USD for three locations • environmental monitoring program: 30,000 USD/year
	Technology	• WAJ &/or MOMA shall implement the Zibar treatment plant (depends on the selected location; MOMA if in landfill land and WAJ if in WWTP land. • Zibar generation is only seasonal (85 days between mid October till mid of January) and hence, the design flow-rate should be based on the flow during peak season (1,750 m3/day for north, 550 m3/day for middle, and 200 m3/day for south). The forecasting of Zibar generation should be studied in further details before finalizing the treatment plant designs. • Evaporation ponds (lagooning) are the most suitable and feasible technology for Zibar treatment. It has been proposed by the study funded by the European and Investment Bank (EIB) as part of the Horizon 2020 Program; 'Integrated Solid Waste Management in Al-Ekaider – Jordan' in 2012, a technical description and conceptual design has been provided in the October 2012 Feasibility Study Integrated Solid Waste Management in Al-Ekaider' submitted to the Ministry of Municipal Affairs and to the WAJ representative member of the committee for review and comments. It is being also included in the proposal being prepared by the MoEnv for Zibar treatment to be submitted to the prime ministry. • This technology is a combination of evaporation ponds with solids removal in sedimentation tanks and sludge stabilization by addition of lime. Lime addition in Zibar sludge does not cause any problems to the sludge's composting process if appropriate dosing is done. • The phases of the plant are the following: Tanker receiving station; Collection / equalization tank; Constant flow pumping station; Chemical dosing with lime; Sedimentation tanks; Zibar sludge removal; Oil – grease removal; Oil separation with centrifugal system; Distribution chamber; Two stage lined evaporation lagoons; Sludge dewatering lagoon; Composting of dewatered Zibar sludge; and Recirculation of water in the compost unit. • The minimum area proposed for the evaporation lagoons for the northern governorates was proposed by Horizon 2020 to be 58,055 m2. However, this area should be revisited since the calculations were based on 68 days season and not 85 and on 1381 m3/day of Zibar and not 1,750	• Based on the findings of the feasibility study as part of the Horizon 2020 Program, the following tariff implications are concluded for the ZTP in the north region (70% or the Zibar quantities): ▪ Investment cost (CAPEX) was estimated to be 6,948,285 USD. ▪ Yearly operational cost (OPEX) for ZTP (chemical and materials, and the personnel cost) is estimated to be around 338,000 USD/year

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
		m3/day. According to the calculations all Zibar will have evaporated before the new production period starts. Some suspended solids remains in the Zibar from the sedimentation tanks. These solids will sediment at the bottom of evaporation lagoons. Every 5-6 years, sludge will need to be removed from the evaporation lagoons (manually, due to the geosynthetic nature of the underlying membrane) and sent to the sludge lagoon. • Layout and plan for the ZTP design (further detailed drawings are provided by the Horizon 2020 study):  	
	Tariff and cost recovery	• MoEnv should cooperate with WAJ &/or MOMA to study the existing tariff setup for Zibar disposal and prepare directional policies for cost recovery that reduce cost of environmental management, but ensure compliance and environmental protection. The tariff structure will depend on the funding scheme for the new Zibar treatment plant (direct Govt funding, private investment, partial Govt investment …etc). As it stands, if the Zibar treatment plant were to be implemented, there is only one source of revenue and that is the Zibar disposal fees. There is no link with actual quantities of Zibar disposed in landfill and it varies between the north and the south regions. Tariffs should be set based on quantity rather that fee per production line which	• Based on the above capex and opex costs vs. the current effective zibar fees, the Horizon 2020 concluded that the revenue growth rates are declining and that revenue growth ranges

Phase	Area of intervention	Improvement Recommendation	Investment/Costs
		would be more equitable to mills, as they would pay for what they produce, and avoid the possibility of mills cross-subsidizing others due to differences in production line output. • Based on Horizon 2020 study for the north region, the amount of funding required for developing and operating the project over the 13 years of the project period stands at € 6.58 million (8.9 million USD). • Horizon 2020 found that: Net Present Value and Internal Rate of Return estimations were negative and pointed towards the rejection of the project from a financial point of view, ZTP not financially valuable investment, need to find alternatives to fund the deficit in Capex and Opex, ZTP will never be able to cover its OPEX at the existing tariff. • Increase tipping fees from 330 JD/production line/season to 1320 JD/production line/season if no funds available to cover CAPEX • Increase tipping fees from 330 JD/production line/season to 409 JOD/production line/season with Govt funding for CAPEX • It is suggested that the government could contribute to the ZTP development CAPEX and increase gradually the tipping fee to cover the OPEX. If the government paid the full ZTP CAPEX cost, then the tariff to cover the OPEX would need to be increased to 409 JOD/production line.	from 1.3% to 1.5%, which is considered a weak growth rate. • The Horizon 2020 feasibility study found that one of the possible options is to increase the tipping fee of the Zibar disposal to cover the plant cost. In the case of a full cost coverage (CAPEX and OPEX), the fee has to be increased by around 250% to 300% by year 13 in order to achieve a viable financial investment (1.35 USD/m3 up from the current 0.31 USD/m^3). CAPEX should be covered by funds allocated by the responsible authorities.

U.S. Agency for International Development

1300 Pennsylvania Avenue, NW

Washington, DC 20523

Tel: (202) 712-0000

Fax: (202) 216-3524