Activity EFH-PS-4 Support hazardous waste management

Task 4 and 5 deliverables: Report on the review and development of a national institutional setup for Hazardous Waste Management in Palestine including proposals for acceptable levels of hazardous substances in disposed waste

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V2 - Revised based on a dedicated consultation meeting and follow-up discussions with the EQA on 27 Nov 2018 in Ramallah	Report on a draft national hazardous waste management institutional set up Report on the review and development of a national institutional setup for Hazardous Waste Management in Palestine including proposals for acceptable levels of hazardous substances in disposed waste	Stavros Vlachos	Prof. Michael Scoullos

THE SWIM AND H2020 SUPPORT MECHANISM PROJECT (2016-2019)

The SWIM-H2020 SM is a Regional Technical Support Program that includes the following Partner Countries (PCs): Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, [Syria] and Tunisia. However, in order to ensure the coherence and effectiveness of Union financing or to foster regional co-operation, eligibility of specific actions will be extended to the Western Balkan countries (Albania, Bosnia Herzegovina and Montenegro), Turkey and Mauritania. The Program is funded by the European Neighbourhood Instrument (ENI) South/Environment. It ensures the continuation of EU's regional support to ENP South countries in the fields of water management, marine pollution prevention and adds value to other important EU-funded regional programs in related fields, in particular the SWITCH-Med program, and the Clima South program, as well as to projects under the EU bilateral programming, where environment and water are identified as priority sectors for the EU co-operation. It complements and provides operational partnerships and links with the projects labelled by the Union for the Mediterranean, project preparation facilities in particular MESHIP phase II and with the next phase of the ENPI-SEIS project on environmental information systems, whereas its work plan will be coherent with, and supportive of, the Barcelona Convention and its Mediterranean Action Plan.

The overall objective of the Program is to contribute to reduced marine pollution and a more sustainable use of scarce water resources. The Technical Assistance services are grouped in 6 work packages: WP1. Expert facility, WP2. Peer-to-peer experience sharing and dialogue, WP3. Training activities, WP4. Communication and visibility, WP5. Capitalizing the lessons learnt, good practices and success stories and WP6. Support activities.

Disclaimer:

TABLE OF CONTENTS

ABBREVIATIONS

CDW	Construction and Demolition Waste
EQA	Environmental Quality Authority
GS	Gaza Strip
HZW	Hazardous Waste
MoA	Ministry of Agriculture
MoF	Ministry of Finance
MoH	Ministry of Health
MoHE	Ministry of Higher Education
MoLG	Ministry of Local Government
MoNE	Ministry of National Economy
MoT	Ministry of Transportation
MS	Member States
NHWMP	National Hazardous Waste Management Plan
NMWRGL	National Medical Waste Regulations and Guidelines by Law
OMW	Oil Mill Wastewater
PFI	Palestinian Federation of Industries
PENRA	Palestinian Energy and National Resources Authority
PSI	Palestine Standards Institution
PWA	Palestinian Water Authority, PWA
PCBS	The Palestinian Central Bureau of Statistics
PENRA	Palestinian Energy and Natural Resources Authority
UNEP	United Nations Environment Program
WB	West Bank
HACCP	Hazard Analysis and Critical Points

PREAMBLE

The need for developing a Policy Framework on Hazardous Waste Management, has become increasingly important in Palestine. Under the umbrella of the National Strategy for Solid Waste Management, the Palestinian Authorities have identified the urgent need to proceed with the development and implementation of a Plan, in order to tackle the growing issue of handling Hazardous Waste. The increasing population and the major, potentially negative, impact on public health that Hazardous Waste (HZW) poses, has been considered as a major challenge for Palestine. Several issues such as improper handling, absence of separation, proper treatment and proper disposal of HW are evident due to the lack of an adequate legislative framework and very limited relevant experience and tradition. The legal and institutional provisions under which HZW is managed, can be characterized as incomplete and weak in terms of monitoring, controlling and enforcing the whole procedure.

To this end, Palestine requested from the SWIM-Horizon 2020 SM Expert Facility, support on Hazardous Waste Management which constitutes Activity EFH-PS-4 of the Environmental/Horizon 2020 Component.

This document is the deliverable of Task 4 and 5 of the activity EFH-PS-4 of the SWIM H2020 SM Project, on the review and development of the national institutional setup for Hazardous Waste Management including proposals for acceptable levels of hazardous substances in disposed waste. A first draft was presented and discussed at a dedicated consultation meeting that took place on the 27th of November 2018 in Ramallah (Task 5: National consultation on the proposed institutional set up) as well as on bilateral discussions with the Environment Quality Authority following the consultation.

Further information on the National consultation can be found in Annex (agenda and main outcomes of the meeting, list of participants).

1. REVIEW OF THE NATIONAL MASTER PLAN FOR HAZARDOUS WASTE IN PALESTINE

The present review is based, to a large extent, on the National Hazardous Waste Master Plan (NHWMP) which provides a good background about hazardous waste management practices in Palestine, by summarizing all open sources/works carried out in this field, until the date of preparing the report (2011). Since the report was conducted seven years ago, several developments have been noted. Yet, relatively little relevant and accurate scientific information is available on national quantitative/qualitative production of hazardous wastes, or on treatment and disposal strategies.

The main goal and priority of the NHWMP was to achieve a sustainable and environmentally sound and acceptable management of HZW. It was prepared in accordance with the Palestinian Authority Environmental Law number 7 of the year 1999 and as translation of articles 11 to 13 of the Law (classification, handling and transportation of HZW).

The methodology adopted in the report is in agreement with the Basel convention methodology for carrying out inventory data on HZW. There is an effective participation of national institutions, ministries and organizations involved in the HZW sector. These include EQA, MoH, MoLG, MoNE, PSI, PIEFZA, PFI, MoF, PWA, MoA, MoT and MoHE. Their main role was to facilitate the effort and to verify the data presented in the report. Stakeholders' participation was clearly shown in the report through the accomplishment of an inventory, a strategy and a capacity building program on the NHWMP.

The main actions of the NHWMP are directed towards the improvement of the weak standards and to addressing problems for handling HZW in Palestine, particularly the problems of environmentally unsafe disposal of HZW at municipal sites and other dumpsites, which do not meet any environmental standards and need urgent improvement. This was clearly reflected in the priorities of the NHWMP strategy and capacity building programs.

Although the inventory data is an initial attempt to summarize the existing Palestinian hazardous waste management situation, one should bear in mind that it is a draft version and contains a number of limitations that should be taken into consideration when updating such data on a regular basis.

In general, all sections of the NHWMP report, satisfy the requirements needed for the environmentally sound management of waste, subject to the Basel convention. They provide a firm legal basis upon which the authorities are able to regulate any operations related to HZW import/export issues. This was evident from the provided forms and guidance to the national competent authority in making a decision whether to consent to or reject a proposed trans-boundary movement of waste subject to the Basel Convention. This is essential as Palestine does not have available adequate facilities to dispose HZW in a manner which will safeguard health and the environment.

2. MAJOR POLLUTING INDUSTRIES

The efficient and timely promotion of a National Strategy or Plan for HZW Management in Palestine requires a strategic and targeted approach that takes into account the steps and measures already initiated and the more pressing urgent needs. The Horizon H2020 SM, in very close cooperation with the EQA and with inputs from different stakeholders, has concluded that interventions need to be focussed on a number of priority sectors, active in the country, that produce the larger quantities and/or the most dangerous hazardous wastes.

In addition, HZW that could be handled locally (e.g. waste from olive oil mills), constituting the "lower handing fruits", should also be included in the priority sectors.

Based on the above approach, the following seven sectors were formally identified by the EQA as major priorities to be tackled first:

- Olive oil mills
- Handling and treatment of used oils
- Bitumen production and handling
- Coating of furniture and wood material
- Dyes and pigments
- Aluminium coating processes
- Pharmaceutical industry

For each of the seven sectors, in the following chapters, there is a detailed process description based on technical documents from similar facilities in Europe. The origins of the HZW within the process are highlighted and commented on. Following the process description, the hazardous waste streams for solid and liquid wastes are identified and described. The best available techniques (BATs) for the management of the aforementioned waste streams are then described based on the currently implemented technology throughout Europe, including in some Mediterranean countries.

3. HAZARDOUS WASTE MANAGEMENT - BASIC ASPECTS

Hazardous Waste Management includes a series of activities, interventions and measures that are taken in various combinations. In each, there are good or "better" practices, which are presented in this section. The major aspects of Hazardous Waste Management are presented, along with a brief description of the proposed actions, which concern the authorities, managers, as well as the HZW generators and key stakeholders involved in all phases of HZW management:

- **Capacity building for the Strengthening of a Hazardous Waste Department and staff training**. Scope/aspects to be considered: Policy/regulation; permitting of HZW services and facilities; tendering and contractual issues; technical guidance; support to monitoring / enforcement / inspection.
- **"Needs assessment" for monitoring / inspection & enforcement, including pilot projects**. Scope/aspects to be considered: A comprehensive control system over the movement, recovery, treatment, and disposal of the wastes is required in order to minimize the possibility of their causing damage to human health, or harm to the environment. The degree of control needed can best be decided initially at a national level in a form which can be translated locally, taking into account local circumstances in relation to the properties of the waste. Controls and management regimes could be applied uniformly in Palestine in respect of hazardous wastes. The control systems required should seek to provide controls over the storage of waste produced, its movement from the generator to the site of its eventual storage, recovery or disposal. The concept of a "Duty of Care" could be provided, under which waste generators, producers and other related stakeholders, maintain a responsibility for the environmentally sound management of all wastes they produce from their generation to their eventual recovery, disposal and post disposal management of residuals.
- **Innovative web-based technologies for hazardous chemicals and waste management In Palestine**. Scope/aspects to be considered: One of the key advantages of using specialised web-based tools, is to improve hazardous chemical and waste programs through which multiple sectors and materials can be targeted simultaneously. This project would focus on three target groups: Hazardous chemical lists and suppliers, hazardous chemical consumers; and HZW generators.
- **Implementation of HZW disposal fee/surcharge**. Scope/aspects to be considered: Regulations and technical standards for (interim) disposal; management of funds and financing/co-financing criteria and conditions.
- **Guidelines for cost recovery measures**. Scope/aspects to be considered: Promote the gathering together of knowledge and information on the impacts of waste, so that their socio-economic effects can be considered, particularly in respect of prevention versus disposal. Promote the application of a prevention program starting from waste minimization in selected sectors. This includes a careful understanding of hazardous materials and their chemical properties.

- **Feasibility studies for bankable projects on hazardous waste and medical waste segregation at source**. Scope/aspects to be considered: Technical concepts; institutional and financial arrangements; legislation & technical standards; tender documents.
- **De-commissioning / Closure and reclamation of industrial hot spots**. Scope/aspects to be considered: Risk assessment; technical design and cost estimates; tender documents; post closure monitoring needs; donor consultations.
- **De-Commissioning / Closure and reclamation of existing landfills; cleaning old industrial/disposal sites**. Scope/aspects to be considered: Risk assessment; technical design and cost estimates; tender documents; post closure monitoring needs; multistakeholder consultations including with funders.
- **Pilot "compliance scheme" for tire recovery**. Scope/aspects to be considered: Targets for tire recovery; regulations; "compliance scheme"; institutional arrangements and financing options (taxes, surcharges); monitoring. Establishment of collection infrastructure (transportation and storage), small scale unit for the crushing of tires, and a test site facility for recycling crushed tires as raw material for road or sport facilities construction with bitumen; use as alternative fuel in the cement industry.
- **Toxic use reduction**. Scope/aspects to be considered: Avoid the use of hazardous substances where less hazardous materials could substitute hazardous ones without detrimental effects or other risks on product or service quality and without incurring excessive economic costs. Whenever possible, promote the adoption of environmentally sound methods of resource recovery by direct reuse, alternative use reclamation, or recycling.
- **Introducing, mandating and strengthening education and awareness on hazardous waste for a series of target audiences directly involved with HZWM**. Scope/aspects to be considered: Educate HZW generators of the dangerous nature of the materials they produce/handle/use and their impact on the environment and how to select and use alternative, less hazardous material. Promote education on HZW at the level of higher education on the adverse effects of hazardous waste on the environment, including the active involvement of Technical Universities and institutions to disseminate such information. For that purpose, a cleaner production centre could contribute, to provide training and capacity building for HZW stakeholders. Capacity building should include: (a) waste prevention audits which should be promoted to qualitatively and quantitatively identify hazardous inputs, wastes and products. Promotion and stimulation of HZW reduction/ minimization in all sectors and phases of management; Improve inter-stakeholder cooperation.
- **Active encouragement of cleaner production techniques (reducing therefore also production of HZW)**. Scope/aspects to be considered: (a) Minimize and eliminate, where possible, the generation of waste; as well as develop and apply a waste prevention strategy. (b) Promote and continue to strengthen the effectiveness of international co-operation in the field of waste management, particularly that involving the transboundary movement of hazardous wastes. This process should include its control and monitoring in accord with international legal instruments. This will be along the lines of those already set up by UN Environment and other international organizations.

- **Strengthen Education for Sustainable Development at all levels of education** with specific programs on HZW. Scope/aspects to be considered: Relevant courses and lessons to be enriched with useful knowledge and experience-sharing on HZW and its management.
- **Creating favourable conditions for private sector involvement**. Scope/aspects to be considered: promotion of partial tax rebate principle for less hazardous waste generators/ importers, etc.
- **Emergency Response plan**. Scope/aspects to be considered: Early emergency response of any hazardous waste contamination, setting up contingency plans for reduction of hazardous and dangerous waste impacts. Public awareness on how to deal with HZW emergency cases.
- **Establishment of a Pollutant Release Transfer Register (PRTR).** Scope/aspects to be considered: Establishment of a technical working group to elaborate technical guidelines and regulations for the trans-boundary notification and movement of hazardous waste from (and eventually also to) Palestine in line with the Basel convention. When applying the waste hierarchy, the authority is required to take measures to encourage options that deliver the best overall environmental outcome (BOEO) for all waste, including hazardous waste. If there is deviation from the hierarchy, robust evidence would have to be provided that shows that there were benefits in terms of the impacts on the generation and management of such waste. The BOEO is a broad concept, steering the overall waste management and is only applicable to an individual waste stream when there is deviation from the established hierarchy.
- **Application of the waste hierarchy.** Scope/aspects to be considered: Hazardous wastes are managed by waste producers and waste managers in accordance with the waste hierarchy. In applying the hierarchy, HZW producers and managers, opt for HZW management that considers the resource value of hazardous wastes, and the need for health and safety to be ensured throughout the management and deliver the best overall environmental outcome (BOEO). This may require establishment and management of specific HZW streams that deviate from the hierarchy (as long as this is justified based on life-cycle thinking and the overall impacts of the generation and management of such waste).
- **Provision of infrastructure.** Scope/aspects to be considered: The Authorities should look to the needs as well as the market for the development or enhancement of a HZW infrastructure. It should be able to support the hierarchy for the management of hazardous waste and meet the needs to ensure that the country as a whole is self-sufficient in hazardous waste disposal. Facilities are put in place for hazardous waste recovery, while the proximity principle is met.
- **Reduce reliance on landfill and incineration.** Scope/aspects to be considered: The reliance on landfills is constantly reduced for HZW and is only used if there is no better recovery or disposal option. Landfilling is the disposal option of last resort and is at the bottom of the hierarchy. Deep underground storage of hazardous waste, which is also a disposal operation and is permitted as a landfill operation in several cases within the EU, is an option for certain difficult-to-manage hazardous waste streams such as metallic mercury (where permitted) or air pollution control residues. High temperature incineration without energy recovery is also a non-preferable disposal operation, which offers a better treatment option than landfilling for certain intractable waste streams. Energy recovery as either a waste recovery operation or a waste disposal operation is an option of higher priority than disposal by incineration without energy recovery or landfilling.

- **Avoidance of mixing or dilution.** Scope/aspects to be considered: Where hazardous waste generation cannot be prevented, waste producers and waste managers should:
  a. avoid mixing different categories of hazardous waste, or mixing hazardous waste with other waste, substances or materials, unless under the terms of an environmental permit, and the mixing operation conforms to Best Available Techniques.
  b. avoid treating hazardous waste by dilution of hazardous substances, and,
  c. keep organic hazardous waste fractions separate from other streams in order to assist their subsequent management in line with the hierarchy.

4. HAZARDOUS WASTE EXAMPLES FROM EU COUNTRIES

In this chapter, the management (technical and institutional) setup, regarding the handling of Hazardous Waste for the six specific sectors mentioned above, are presented, based on good practices from selected European Countries.

5.1 Olive oil mills

Olive mill waste water (OMW) is considered as one of the most polluting waste waters from the food sector and causes great problems in biota and cultivations if discharged untreated in soil or aquatic systems. It has a very high COD, i.e. 200 000 mg/l, a low pH, i.e. 3–5.9, and a high content of solid matter, i.e. TSS 20 000 mg/l. In addition, the high polyphenol content of olive mill waste water. up to 80 000 mg/l, make it “hazardous” and inhibit the bacterial degradation giving them phytotoxic characteristics.

5.1.1 Legislative Framework

The legal framework on olive oil mill waste of the three most important olive oil producing EU countries, is reviewed herewith.

Greece

Greece follows the legislation of the European Union and in particular the Waste Framework Directive (2008/98/EC), which includes rules on hazardous waste and waste oils and requires Member States to recycle at least half of their household and general waste by 2020. According to the hierarchy, waste should be dealt with first by prevention, then re-use, recycling, recovery and finally, disposal. During recovery, waste is either converted into usable forms of material or is incinerated so that energy is recovered.

The Greek legislative framework consists of Joint Ministerial Decision (KYA 127402/1487/Φ15/7-12-2016) that allows the controlled application, after a pre-treatment, of OMW to olive orchards and other crops at a maximum quantity 80 - 200 m^3/ha, depending on the specific climatic and soil conditions, which need to be studied and monitored.

Spain

The European legislative framework on hazardous waste and waste oils (2008/98/EC), applies also to the Spanish legislation which includes the implementation of Law No. 4/2011 on sustainable economy. The main target of the plan is to enhance resource efficiency through the promotion of waste prevention and a sustainable management of waste. The Law encourages second extraction for energy recovery, composting and use in agriculture, disposal in evaporation ponds, and use of wastes for animal feeding.

Italy

Italy has special legislation for the disposal and/or recycling of olive processing wastes. Land spreading of wastes arising from olive processing is specifically regulated under the Law no. 574 of 11/11/1996 on OMW and olive cake. Italian legislation integrates the relevant European Directive within the aforementioned law, following the typical disposal scheme proposed by relevant European guidance standards.

5.1.2 Olive oil mill best environmental management practices

Oil mill wastewater possesses a double nature. It is a strong pollutant and at the same time a possible source of valuable components, such as polyphenols, flavonoids, anthocyanins, inorganic trace elements, etc., that could be isolated (removed) and economically exploited. A large number of treatments/technologies (physical, chemical, and biological) have been tested in many countries, and these methodologies could be classified in the following categories:

- Detoxification processes (aerobic and anaerobic, physicochemical)
- Processes for production of various products (fertilizers, compost, antioxidants, biopolymers, animal feed)
- Integrated processes aiming at energy recovery (biogas, electricity)
- Combined processes.

Detoxification Processes

They aim at ‘‘cleaning’’ the waste so as to allow its safe, subsequent disposal in water or soil reservoirs. The most important processes are biological and physicochemical.

a. Biological processes: Use of microorganisms to break down the chemicals present in OMW. They are divided into aerobic and anaerobic processes according to the type of the micro-organisms used.

b. Physicochemical Processes:

Neutralization, Precipitation/Flocculation: these involve the use of additional chemicals in order to destabilize the suspended and colloidal matter of OMW and form an insoluble solid that can be removed easily from the waste.

Oxidation processes: Several oxidizing agents have been tested for OMW treatment like hydrogen peroxide, ozone, chlorine, chlorinated derivatives in combination with ultraviolet radiation (Advanced Oxidation Processes).

c. Thermal Processes: Manmade heat sources or a natural source of thermal energy (air, sun) are used. The most important thermal processes are evaporation, lagooning (natural evaporation) and pyrolysis. The main drawback of these processes is related to the post treatment and disposal of the produced emissions.

d. Membrane Processes: Membranes are effective for separation of oil-water mixtures without adding solvents. With ultrafiltration, only a small amount of retentate (waste) is produced (permeate is 90–

95% of the volume of the feed) and very high removal of lipids is achieved. Main problems are the high capital costs and the need of qualified personnel, making them non-affordable for small oil mills.

Processes aiming at the production of various products

OMW may be regarded as an inexpensive source of inorganic and organic compounds to be recovered because of their potential economic interest or their potential to be transformed into products for use in agriculture, biotechnology, and the pharmaceutical as well as the food industry.

a. Production of Fertilizers (Recycling of the Waste at Land) Biofertilization or Bioremediation: OMW should not be directly applied on soil and crops because of its phytotoxic properties.

Treating OMW with an enriched aerobic microbial population results in a non-phytotoxic thick liquid that could be characterized as an organic soil-conditioner/ biofertilizer.

Composting refers to the process of controlled aerobic biological degradation of organic substrates (wastes, residues, etc.). In the case of OMW composting, OMW quantities are added to the solid substrate during the thermophilic stage to replace the evaporated water.

b. Recovery of Antioxidants: OMW contains water-soluble compounds with potential antioxidant properties, like polyphenols, flavonoids, anthocyanins, tannins, oleanolic acid, and maslinic acid. The processes of extraction of antioxidants of high added value from OMW are patented.

c. Production of Biopolymers: The production of biopolymers from OMW is a very interesting alternative, studied during the last years due to the high added value and excellent properties of these substances. The two main categories of these substances are: exopolysaccharides and polyhydroxyalkanoates.

d. Production of Animal Feed: Olive cakes or solid residues of various OMW processes could be used in animal feeding, as they are rich in oil, carbohydrates, and proteins. Problems arise from OMW's high concentration of potassium and phenolic compounds which are anti-digestive factors.

Usually, small olive mills, use evaporation lagoons. Allowing their waste water to evaporate in open lagoons for months, leads to stale odours and, in many cases, leakage causes groundwater contamination. The solid residue is then sent for land spreading. Direct deposition in olive groves can result in groundwater contamination. Connection to a MWWTP is not usually possible, as olive mills are normally in rural areas where MWWTPs either do not exist or are not designed to treat such waste water. Thermal concentration/thickening can also be used to treat olive oil waste water.

Olive mill wastewater can also be treated using an anaerobic WWTP, which can reduce COD emission levels by 65–95 %. This has a high investment cost, particularly because olive oil mills have seasonal harvesting. The campaigns are carried out between October and March. The seasonal characteristic of these mills does not affect the treatment as an anaerobic digester can be easily restarted after a dormant state, although it takes some time to re-establish treatment conditions.

The high polyphenol content of the waste water inhibits the growth of aerobic bacteria. In addition, the autoxidation of phenolic compounds during contact of the olive oil wastewater with air leads to the formation of macromolecular polyphenols which are even more difficult to degrade.

A further alternative treatment of waste water from olive mills can involve an effective primary treatment such as sedimentation to remove solids. Using precipitation, with the selection of an optimal flocculation agent, eliminates a very high percentage of the dissolved and particulate organic matter which will then be removed by filtration. The final step consists of applying membrane separation to ensure 95 % reduction of the organic load. This is still under investigation but could be a solution for the future.

Other technologies include soil application [1]:

- Composting (in windrows, in U-lane)
- Electro-coagulation
- Aerobic biological trickling filter + constructed wetland
- Evaporation – Hydrolysis–Oxidation: E.H.O.
- Phytoremediation
- Anaerobic digestion in a WWTP
- Bio-fuel pellets
- Filtration with sawdust & phytoremediation

5.2 Handling and treatment of used oils

For most plants handling and treating used oils, the following order is relevant: a) pre-acceptance, b) acceptance, c) storage, d) treatment, and e) storage of residues and emissions. Each of these previously mentioned steps requires knowledge and control of the waste as well as specific acceptance and processing management. Knowledge of wastes, before they are accepted and treated, is a key factor for the management of a waste treatment plant. For used oils, the major best management practices are the following:

- Treatment applied mainly to recover materials from the used oils (recycling)
- Treatment primarily aimed at producing material to be used as fuel

There are two main options for the treatment of waste oils. The first option is the treatment of the waste oil for the production of the material that will be used mainly as fuel or for other uses (e.g. absorbent, mould release oil, flotation oil). These include treatments such as cleaning of waste oil, thermal cracking and gasification. The second option is to treat the waste oil and reconvert it to a certain material that can be used as a base oil to produce lubricants. This latter way is referred to as 're-refining'. A lot of treatment processes exist (or are currently under development) in Europe. The most significant ones are listed below [2]:

- Reuse (laundering, reclamation)
- Re-refining (pretreatment, cleaning, fractioning, finishing)

- Thermal cracking
- Gasification
- Severe or mild processing (solvent extraction, propane extraction, etc.)
- Recycling

The method of re-using a waste oil to produce a lubricant, requires cleaning or re-refining. These processes involve the removal of impurities, defects and any leftover products from its old use. Generally, this type of process removes all impurities and additives and only base oil then remains. Subsequently, lubricant producers add substances to attain the specifications of a virgin product.

The main processes used in oil recovery plants are shown below:

• Pretreatment of waste oil to dewater (removal of water), de-fuel (removal of light ends and fuel traces such as naphtha, etc.) and remove sediments. This pretreatment process does not compare with the other oil treatment systems because it does not yield an end-product, nor does it achieve the final aim of treatment.

• Cleaning of waste oil includes deasphalting and the removal of asphaltic residues: heavy metals, polymers, additives, other degradation compounds.

• Fractionation of waste oil involves a separation of the base oils using their different boiling temperatures, to produce two or three cuts (distillation fractions).

• Finishing of waste oil/ final cleaning of the different cuts (distillation fractions) is carried out to achieve specific product specifications (e.g. improve colour, smell, thermal and oxidation stability, viscosity, etc.). Finishing may also include the removal of PAHs in the case of a severe (high temperature and high pressure) hydro finishing or solvent extraction (low temperature and low pressure).

5.2.1 Legislative Framework

United Kingdom

The UK's Strategy underpins the practical application of the revised Waste Framework Directive (2008/98/EC) and in particular the requirements that apply to hazardous waste, including waste from used oils, in relation to the waste hierarchy, the treatment of hazardous waste, and the provision of infrastructure. The Strategy comprises of the following [3]:

- Six high level principles for the management of hazardous waste.
- A set of outlines of "decision trees" to assist waste producers and waste managers to make the right decisions about the management of their waste and the investment in infrastructure to help move hazardous waste management up the waste hierarchy.
- A timeline of action on issues relating to the introduction and implementation of the strategy.
- A list of guidance relating to the treatment of HZW.
- An updated summary of the facility needed.

Greece

Greek policy is also aligned with and integrates the revised Waste Framework Directive (2008/98/EC). Therefore, waste management is undertaken according to the principle of the EU waste hierarchy. The hierarchy applies as a priority order:

a. Prevention

b. Preparing for re-use

c. Recycling

d. Other recovery, e.g. energy recovery, and

e. Disposal.

Prevention includes measures that reduce the adverse impact of hazardous waste on the environment and human health and measures that reduce the content of harmful substances in materials and products before they become waste, as well as a reduction in the quantity of hazardous waste produced.

5.2.2 Treatment of used oils best management practices from the UK

Thermal desorption for oily sludges from cars

Oil sludge or black sludge is a solid or gel waste of motor oil caused by the oil gelling or solidifying, usually at temperatures higher than 100 degrees Celsius. Oil sludge can be a major contributor to internal combustion engine problems. In the UK some 60,000 tons of oily sludge and oily filter cakes arise each year. Over the past two years thermal desorption plants have emerged as the most sustainable treatment option. These plants enable the recovery of oils from the wastes and in some cases the solids, so are higher up the waste hierarchy than incineration or landfill and reduce the need for such treatment.

5.3 Bitumen production & use and Asphalt Reuse

Bitumen is a residue derived from certain crude oils (e.g. Middle East, Mexico or South America) after vacuum distillation has removed waxy distillates. Bitumen is normally mixed with other components (e.g. gravel) to produce asphalt that is used in road paving, roof coating and pipe sealing or coating. Bitumen production only appears in some refineries (45 % of the EU refineries).

What is perhaps useful for Palestine, is to define the types of bitumen most appropriate for the specific uses needed in the country and keep records of the basic properties/parameters that characterize each batch-use.

Known for its adhesive and cohesive assets, bitumen is mostly utilised in the construction industry. Bitumen is applied on road paving because it is viscous when hot, but solid once it cools down. Therefore bitumen operates as the binder/glue for pieces of the aggregate, the asphalt.

Bitumen is applied alone or as asphalt mixture with sand and gravel in construction and maintenance of:

- Highways
- Airport runways
- Footways / Pedestrian Ways
- Car parks
- Racetracks
- Tennis courts
- Roofing
- Damp proofing
- Dams
- Reservoir and pool linings
- Soundproofing
- Pipe coatings
- Cable Coatings
- Paints
- Building
- Water Proofing
- Tile underlying waterproofing
- Newspaper ink production
- many other applications

Significant quantities of asphalt are produced, some of which are effectively recycled. They are classified under the EU catalogue of construction and demolition waste (code 1703). Construction and demolition waste (CDW) has received considerable attention in the past few years as it is a lens to understanding the potential for resource efficiency improvement in the overall construction sector. Indeed, construction activities are the main source of waste in the EU and currently, an important part of this flow is made of materials that can be readily recycled (glass, concrete, asphalt, etc.) but with a recycling potential still under-exploited. Moreover, recycling performances between EU Member States differ significantly (from 10% to 90%), showing that not only Palestine and non-EU countries but also EU Member States with low recycling performances can certainly improve by applying good practices developed in “champion” EU countries. The potential to increase the construction sector’s resource efficiency by increasing the CDW recycling rate, is significant.

However, identifying and transferring good practices in this sector is not an easy task. In fact, practical management of CDW varies greatly from country to country (due to local variations in context, legislation, enforcement, and construction practices). Moreover, monitoring and data reflecting the recycling performance are often not accurate, due to traceability and availability issues. Monitoring performances in recycling CDW is a real challenge that even the Member States and European authorities are facing, although there is a general consensus, that obtaining reliable stabilization is an essential step in evaluating progress toward recovery targets.

5.3.1 Bitumen production/properties

In order to realize the complexity of bitumen as a product, an in-depth knowledge and detailed understanding of one way the roads are built is crucial. Specialists in bitumen know bitumen as an advanced and complex construction material, not as a mere by-product of the oil refining process. The ultimate paving material (also referred to as hot mix asphalt concrete – HMAC or HMA) consists of about 93 – 97% mineral aggregate (stone), sand and filler. The remaining percentage is bitumen.

The desired properties of bitumen may be achieved either by adjusting distillation conditions or by 'blowing'. In the latter process, air is blown into hot bitumen causing dehydrogenation and polymerisation reactions and creating a harder product with higher viscosity, higher softening point and a reduced penetration. (The penetration, often used as the main criterion, refers to the depth of penetration by a standard needle in a bitumen sample at standard conditions). The properties of the blown bitumen are determined by the residence time in the oxidation vessel, the air rate and the liquid temperature. If any of these parameters are increased, the penetration is reduced and the softening temperature is raised.

In most applications, the hydrocarbon feed stream to a bitumen blowing unit (BBU) is the bottom residue stream from a vacuum unit and in some instances the residue (extract) from a deasphalting.

Normally, a number of different grades of bitumen are produced in campaigns and these are further modified by blending with other high-boiling components such as vacuum residue, heavy gas oil or synthetic polymers. In this way, a single blowing unit is able to cater for a wide range of bitumen grades for various applications.

Polymer additives Styrene Butadiene Styrene (SBS), Ethylene Vinyl Acetate (EVA), Natural rubber, etc. are used for heavy duty service bitumen production. They do not change the chemical structure of the bitumen but change its mechanical properties. The polymers modify the bitumen's properties such as the softening or brittleness point, and aim at improving longevity.

Process description

The BBU will either operate on a continuous basis or in batch mode depending on the quality of the vacuum residue feedstock and the required bitumen product specification. Continuous processes are the most common in refineries. Where the bitumen feed is received from storage, an additional fired heater may be required to preheat the feed to a temperature of about 200 – 250 °C, but it can be up to 550 ºC. With a batch-operated BBU, a feed buffer vessel is usually included to store the hot feed stream from the vacuum unit.

The residue feed stream is pumped into the top of the oxidation vessel. The operating pressure in the top of the oxidation vessel is normally around 1 barg and in the bottom around 2 barg, depending on the height of the vessel. As air is sparged into the base of the vessel, oxidation of the residue takes place, resulting in heat. The temperature in the oxidation vessel, which determines to a certain extent the bitumen grade, is normally controlled between 260 °C and 300 °C. Different options are applied for adjusting the temperature, which include the addition of colder feed to the oxidation vessel, the recirculation of cooled bitumen product from the bitumen run down cooler, and in older units direct water quenching. The blown bitumen is removed from the bottom of the oxidation vessel and cooled by rising steam, before being sent to storage.

The air rate is normally well in excess of stoichiometric requirements and so a considerable quantity of oxygen is present in the upper vapour space of the oxidation vessel. To avoid an explosion in the vapour space, in most units, steam is injected at a rate necessary to keep the oxygen concentration below the lower flammable limit (5 – 6 % v/v). In some units, a small amount of water is also injected into the vapour outlet of the oxidation vessel to reduce the vapour temperature. This is sometimes considered necessary to prevent afterburning in the overhead system which could otherwise lead to severe coke formation.

The overhead vapours are first passed through a vent gas scrubber to remove oil and other oxidation products. In most cases, gas oil is used as once-through scrubbing liquid. The vent gas from the scrubber is subsequently cooled to condense light hydrocarbons and sour water, sometimes in a water spray contact condenser or scrubber. The remaining gas, consisting mainly of light hydrocarbons, N2, O2, CO2 and SO2, is incinerated at high temperatures (~800 °C) to ensure complete destruction of minor components such as H2S, complex aldehydes and organic acids and phenolic compounds, which have a highly unpleasant odour.

The majority of the BBUs produce the higher grades of bitumen (roof and pipe coatings) and normally operate continuously throughout the year. The BBUs which are used to produce road bitumens operate only when the demand for road asphalt is high.

4.3.2. Legislative Framework

Asphalt plants, or more accurately asphalt pavement mixing facilities, are industrial operations that mix bitumen binder with crushed rock, gravel, and sand (collectively called aggregates) to make pavement. Bitumen that binds the aggregates together, is one of many distilled products obtained from the oil refining process. Similar to other refined oils, such as lubricating oils, it is processed to meet defined standards. Some mixes also require additives, which can range from chemicals that improve mix performance to natural fibers that strengthen specialty mixes. The use and storage of these materials according to EU legislation (Waste Framework Directive 2008/98/EC) should be carefully monitored and regulated. Asphalt pavement mixing facilities should be well-regulated by environmental agencies, and they employ multiple emission control systems, to effectively reduce risks of fire through auto ignition of condensed vapors as well as undesirable health impacts on workers (see also under best practices section 4.3.3.). The small amount of emissions released from the control systems are closely monitored to ensure that they stay well below any permitted level and they do not pose any health or environmental risk.

Asphalt is directly connected with road construction, changes and maintenance. Different definitions on CDW are applied, even within the EU, which sometimes affect the classification of asphalt, making cross-country comparisons, cumbersome.

The European Commission is introducing the Construction and Demolition Waste Management Protocol (non-binding guidelines) to help practitioners, public authorities, certification bodies and clients of recycled materials to handle properly also the used asphalt/bitumen waste stream. By advocating management of asphalt within the CDW, in line with the waste hierarchy, we contribute effectively to resource efficiency and reduction of use of new bitumen. The Protocol is intended also to raise awareness about legal requirements, as well as promote state-of-the-art techniques.

4.3.3. Bitumen best handling practices

The most important issue for Palestine is the proper storage and handling of bitumen to avoid fire, health and environmental risks.

As described by the European Best Available Technique Reference Documents, bitumen should be kept in proper storage tanks normally under heating conditions and insulated. Bitumen is generally not handled as a solid.

For preventing fire due to auto ignition of condensed vapours, tanks containing oxidised bitumen are equipped with nitrogen blanketing and pressure/vacuum safety valves. These valves need maintenance due to the slime. In some cases, these valves may be removed and a gaseous overhead treatment scheme is used.

Hydrocarbons and sulphur compounds may emanate from leakages (particularly in overhead systems) and pressure relief valves and in the form of liquid droplet-containing aerosols from the venting of tanker top-loading operations.

Loading and unloading of the tank is typically done as follows: when the tank is filled, nitrogen does not flow to the tank, and the pressure is lowered by letting part of the gas go to the atmosphere; when the tank is unloaded at a low speed, a small amount of nitrogen is led to the tank; however, when the speed of unloading is higher, higher amounts of nitrogen must be used. If the tank is equipped with a cleaning system, it is mechanically very simple and easy to clean.

5.3.4 Asphalt reuse best management practices

Recycling or reuse of asphalt pavement material, in situ (in place), by employing movable asphalt/sand reworking machinery is a very simple but powerful concept. Recycling of existing/damaged asphalt pavement materials to produce new asphalt pavement materials, results in considerable savings of material, energy and money. At the same time, recycling of existing material also helps to solve operational, transport and disposal problems. Because of the reuse of existing material, asphalt pavement geometrics and thickness can also be maintained or adjusted accordingly during construction. In some cases, traffic disruption is considerably less than that for other rehabilitation techniques. The specific benefits of recycling can be summarized as follows:

1. Reduced costs of construction.
2. Conservation of aggregate and binders.
3. Preservation of the existing pavement geometrics.
4. Protection of the environment.

5. Conservation of energy.
6. Less user delay.
7. Considerable reduction in transport of material.
8. Zero or minimal disposal of waste.

Reduction of asphalt waste is directly linked to the issue of proper road maintenance. Several studies have shown that it costs highway agencies less if the pavements are kept at a certain acceptable level of serviceability. According to World Bank Sources, each $1.00 spent during the first 40 percent drop in quality will avoid much higher costs needed ($4.00 to $5.00) if the maintenance is delayed until the pavement loses 80 percent of its original quality. Rehabilitation is needed to maintain the pavement at a certain condition ensuring adequate road safety. Rehabilitation of pavement is also needed due to the following reasons:

1. Inadequate ride quality.
2. Excessive pavement distress.
3. Reduced surface friction.
4. Excessive maintenance requirement.
5. Unacceptable user costs.
6. Inadequate structural capacity for planned use or projected traffic.

Recycling is only one of the several rehabilitation alternatives available for asphalt pavements. Some of the other common methods are thick or thin hot mix asphalt (HMA) overlay. The choice of rehabilitation alternative depends on observed pavement distress, laboratory and field evaluation of existing material, and design parameters. Also, maintenance of geometrics and original thickness of pavements, especially in underpasses, influence the choice of rehabilitation method, among which recycling has some unique advantages which are not available with other types of rehabilitation techniques.

The Asphalt Recycling and Reclaiming Association defines four different types of recycling methods: (1) hot recycling; (2) hot in-place recycling; (3) cold in-place recycling; and (4) full depth reclamation.

1. Hot mix asphalt recycling is the process in which reclaimed asphalt pavement (RAP) materials are combined with new materials, sometimes along with a recycling agent, to produce hot mix asphalt (HMA) mixtures. Both batch and drum type hot mix plants are used to produce recycled mix. The RAP material can be obtained by milling or ripping and crushing operation. The mix placement and compaction equipment and procedures are the same as for regular HMA. Typically, 10 to 30 percent RAP is used in recycled hot mixes. The advantages of hot mix recycling include equal or better performance compared to conventional HMA, and capability to correct most surface defects, deformation, and cracking.
2. Hot in-place recycling (HIR) consists of a method in which the existing pavement is heated and softened, and then scarified/milled to a specified depth. New HMA (with/without RAP) and/or recycling agent may be added to the scarified RAP material during the recycling

process. HIR can be performed either as a single pass or as a multiple pass operation. In single pass operation, the scarified in-place material can be combined with new material if needed or desired. In multiple pass operation, the restored RAP material is recompacted first, and a new wearing surface is applied later. The depth of treatment varies between 20 to 50 mm (¾ in to 2 in). There are three HIR processes; (a) surface recycling, (b) repaving, and (c) remixing. This is a type of HIR operation in which the existing asphalt surface is heated and scarified to a specified depth. The scarified material is combined with aggregate and/or recycling agent. The mix is then compacted. A new overlay may or may not be placed in the recycled mix. In the second type of HIR method, repaving, the surface recycling method is combined with a simultaneous overlay of new hot mix asphalt (HMA). Both the scarified mix and the new HMA are rolled at the same time. In the case of remixing, the scarified RAP material is mixed with virgin HMA in a pugmill, and the recycled mix is laid down as a single mix. The advantages of hot in-place recycling are that surface cracks can be eliminated, ruts and shoves and bumps can be corrected, aged asphalt is rejuvenated, aggregate gradation and asphalt content can be modified, traffic interruption is minimal, and hauling costs are minimized.

3. Cold in-place recycling (CIR) involves reuse of the existing pavement material without the application of heat. Except for any recycling agent, no transportation of materials is usually required, and aggregate can be added, therefore hauling cost is very low. Normally, an asphalt emulsion is added as a recycling agent or binder. The emulsion is proportioned as a percentage by weight of the RAP. Fly ash or cement or quicklime may also be added. These additives are effective for over asphalted and low stability mixes. The process includes pulverizing the existing pavement, sizing of the RAP, application of recycling agent, placement, and compaction. The use of a recycling train, which consists of pulverizing, screening, crushing and mixing units, is quite common. The processed material is deposited in a windrow from the mixing device, where it is picked up, placed, and compacted with conventional hot mix asphalt laydown and rolling equipment. The depth of treatment is typically from 75 to 100 mm (3 to 4 in). The advantages of cold in-place recycling include significant structural treatment of most pavement distress, improvement of ride quality, minimum hauling and air quality problems, and capability of pavement widening.

Full depth reclamation (FDR) has been defined as a recycling method where all of the asphalt pavement section and a predetermined amount of underlying base material is treated to produce a stabilized base course. It is basically a cold mix recycling process in which different types of additives such as asphalt emulsions and chemical agents such as calcium chloride, portland cement, fly ash, and lime, are added to obtain an improved base. The four main steps in this process are pulverization, introduction of additive, compaction, and application of a surface or a wearing course. If the in-place material is not sufficient to provide the desired depth of the treated base, new materials may be imported and included in the processing. New aggregates can also be added to the in-place material to obtain a particular gradation of material. This method of recycling is normally performed to a depth of 100 mm to 300 mm (4 to 12 in). The train consists of a recycling machine hooked to a water tanker and steel drum roller with pad foot shell. The advantages of full depth reclamation are that most pavement distresses are treated, hauling costs are minimized, significant structural improvements can be made (especially in base), material disposal problems are eliminated, and ride quality is improved.

5.4 Coating of furniture and wood materials

Wood is a natural raw material characterized by inhomogeneity and anisotropy, which displays irregular properties in terms of surface structures, porosity, electrical resistance, etc. The aforementioned properties, in conjunction with the wide range of uses of wood, differentiate the needs for products of varying contents and different substances (e.g. waxes, oils, resins). Wood fibers often have the characteristic that they swell-up and become erect under the influence of liquids (in particular, with water). Therefore, wooden surfaces are frequently coated, in order to conserve, strengthen or alter the properties, such as the color, surface structure and/or porosity.

Especially for the coating of profiled, wooden workpieces, the base and topcoat are frequently applied via spray applications. Thereby, losses via overspray are generated within the spraying booths in one of two waste forms:

- If wet separation is applied, the overspray forms paint sludge. The paint sludge consists of paint particles, small amounts of organic solvents, coagulation agents and water. Paint sludge is generally regarded as a waste that needs monitoring. In general, the material is used as a fuel in special refuse combustors.
- If the overspray is separated dry, contaminated glass fiber filter mats have to be disposed of. As soon as a specific minimum velocity of the airflow is reached, the filter mats have to be replaced. The filter mats, now contaminated with dried paint particles, generally do not need monitoring and can be used as a fuel in regular waste incineration plants.

Mixed two-component paints cannot be recycled and are disposed of. The solvents are recovered from non-cured paints. In addition, contaminated solvents are generated from the cleaning of application devices, conveyor systems, paint pipelines, spray booths and others. In general, cleaning agents used in the wood industry are recycled via distillation and can be used as recycled cleaning agents. The distillation generates paint leftovers in solid, liquid or paste like forms. Contaminated solvent, solids from distillation, dried 2K paint and other residues and leftovers that are not reused are disposed of, usually as hazardous waste.

Hazardous properties of paint sludge from paint overspray have been analyzed. However, in many cases, there is a lack of overall background data on these kinds of wastes. Therefore, co-operation between paint or lacquer producers, waste producers, environmental authorities, and waste researchers and laboratories is very important in establishing such a data base. For example, in one study, the formaldehyde concentrations were analyzed based on information received from the producers of paints and lacquers. This provided the essential information for overall assessment of the chemical and ecotoxicological hazard of the residues studied. The results confirmed the benefit of combining chemical and ecotoxicological assays in assessing the potential environmental hazard of complex organic mixtures found in paint residue wastes. The pretreatment studies showed that the amount of residues could be minimized by reducing the liquid content of water-curtainbooth residues, and the hazard was decreased by changing the raw materials in the spray painting process to paints and lacquers that contain less harmful solvents.

The results also proved that landfilling is not a suitable method of disposal for the paint residues produced in the furniture industry. For these types of organic wastes, a better alternative method of treatment could be incineration. The information of the ecotoxicological and leaching properties of excess paint residues produced in different spray painting processes helped paint producers to develop their products and makes it possible for furniture producers to choose environmentally safer products. Furthermore, this hazard-screening approach will help furniture producers to improve the surface paint process of furniture making in order to minimise the amount and hazard of the wastes produced.

5.4.1 Legislative Framework

The European policy for the hazardous waste of the coating of furniture and wood material sector, follows the Waste Framework Directive (2009/98/EC). The legislation of Member States has integrated, as mentioned above, this Directive into their national legislative texts.

5.4.2 Coating of furniture and wood material best management practices

The best practices described herewith are based on experiences collected from Greece. Several techniques are employed by companies of this sector. These techniques derive from the environmental permit requirements, which follow the European guidance. These comprise of the following [4]:

- **Minimisation of raw material consumption**

Batch painting/colour grouping

Pig cleaning systems

Online mixing system for two-component products

- **Replacement of solvent-based material using**:

Water-based coatings

Powder coating – conventionally dried

UV radiation curing paints

- **Paint application techniques and equipment**

Rolling and filling by using reverse coaters

Curtain coating (casting)

Flooding

High-volume low-pressure spraying (HVLP)

Electrostatically assisted compressed air, airless and air-assisted spraying

Powder coatings – electrostatically assisted spraying

- **Spray booths**

Wet separation booth

- **Drying**

Microwave dryer

High-frequency dryers

Infrared radiation curing

Near-infrared radiation curing

Ultraviolet (UV) radiation

Electron beam curing

Combined convection/radiation drying (thermal reactor)

- **Waste gas treatment**

Dry particle filter systems

Electrostatic filter

Venturi particle separation

Scrubber

Biological treatment

Thermal oxidation

- **Waste water treatment**

Waste water treatment for wet separation paint spray booths

Ultra and nanofiltration

- **Waste treatment**

Recovery of used solvents by applying distillation

Contaminated solid wastes are generally incinerated, and the flue gases, when acidic, are scrubbed.

5.5 Dyes and pigments

Major solid wastes of concern include filtration sludges, process and effluent treatment sludges, and container residues. Examples of wastes considered toxic, include, wastewater treatment sludges, spent acids, and process residues from the manufacture of a series of dyes and pigments including the chrome yellow and orange pigments, molybdate orange pigments, zinc yellow pigments, chrome and chrome oxide green pigments, iron blue pigments, and azo dyes.

5.5.1 Legislative Framework

As mentioned before, the policy for the dyes and pigments sector HW follows the same rules and directives as the previous cases examined, included in the EU Waste Framework Directive (2009/98/EC).

5.5.2 Dyes and pigments production best management practices

Liquid Effluents

Effluent treatment normally includes neutralization, flocculation, coagulation, settling, carbon adsorption, detoxification of organics by oxidation (using ultraviolet systems or peroxide solutions), and biological treatment. Exhausted carbon from adsorption processes may be sent for regeneration or combustion. Reverse osmosis, ultrafiltration, and other filtration techniques are used to recover and concentrate process intermediates.

Solid Hazardous Wastes

Contaminated solid wastes are in general incinerated, and the flue gases, when acidic, are scrubbed.

5.6 Aluminium coating processes

Aluminium alloys are anodized to increase corrosion resistance and to allow dyeing (coloring), improved lubrication, or improved adhesion. However, anodizing does not increase the strength of the aluminium object. The anodic layer is non-conductive.

When exposed to air at room temperature, or any other gas containing oxygen, pure aluminum self-passivates by forming a surface layer of amorphous aluminum oxide 2 to 3 nm thick, which provides very effective protection against corrosion. Aluminum alloys typically form a thicker oxide layer, 5–15 nm thick, but tend to be more susceptible to corrosion. Aluminium alloy parts are anodized to greatly increase the thickness of this layer for corrosion resistance. The corrosion resistance of aluminium alloys is significantly decreased by certain alloying elements or impurities: copper, iron, and silicon, so 2000-, 4000-, and 6000-series Al alloys tend to be most susceptible.

Although anodizing produces a very regular and uniform coating, microscopic fissures in the coating can lead to corrosion. Further, the coating is susceptible to chemical dissolution in the presence of high- and low-pH chemistry, which results in stripping the coating and corrosion of the substrate. To combat this, various techniques have been developed either to reduce the number of fissures, to insert more chemically stable compounds into the oxide, or both. For instance, sulfuric-anodized articles are normally sealed, either through hydro-thermal sealing or precipitating sealing, to reduce porosity and interstitial pathways that allow corrosive ion exchange between the surface and the substrate. Precipitating seals enhance chemical stability but are less effective in eliminating ion exchange pathways. Most recently, new techniques to partially convert the amorphous oxide coating into more stable micro-crystalline compounds have been developed that have shown significant improvement based on shorter bond lengths.

Some aluminium aircraft parts, architectural materials, and consumer products are anodized. Anodized aluminium can be found on MP3 players, smartphones, multi-tools, flashlights, cookware, cameras, sporting goods, firearms, window frames, roofs, in electrolytic capacitors, and on many other products both for corrosion resistance and the ability to retain dye. Although anodizing only has moderate wear resistance, the deeper pores can better retain a lubricating film than a smooth surface would.

Anodized coatings have a much lower thermal conductivity and coefficient of linear expansion than aluminium. As a result, the coating will crack from thermal stress if exposed to temperatures above 80 °C (353 K). The coating can crack, but it will not peel. The melting point of aluminium oxide is 2050 °C (2323 K), much higher than pure aluminium's 658 °C (931 K). This and the non-conductivity of aluminum oxide can make welding more difficult.

In typical commercial aluminium anodizing processes, the aluminium oxide is grown down into the surface and out from the surface by equal amounts. So, anodizing will increase the part dimensions on each surface by half the oxide thickness. For example, a coating that is 2 μm thick will increase the part dimensions by 1 μm per surface. If the part is anodized on all sides, then all linear dimensions will increase by the oxide thickness. Anodized aluminium surfaces are harder than aluminium but have low to moderate wear resistance, although this can be improved with thickness and sealing.

Process

The anodized aluminium layer is grown by passing a direct current through an electrolytic solution, with the aluminium object serving as the anode (the positive electrode). The current releases hydrogen at the cathode (the negative electrode) and oxygen at the surface of the aluminium anode, creating a build-up of aluminium oxide. Alternating current and pulsed current is also possible but rarely used. The voltage required by various solutions may range from 1 to 300 V DC, although most fall in the range of 15 to 21 V. Higher voltages are typically required for thicker coatings formed in sulfuric and organic acid. The anodizing current varies with the area of aluminium being anodized and typically ranges from 30 to 300 A/m^2 (2.8 to 28 A/ft^2).

Aluminium anodizing is usually performed in an acid solution, which slowly dissolves the aluminium oxide. The acid action is balanced with the oxidation rate to form a coating with nanopores, 10–150 nm in diameter. These pores are what allow the electrolyte solution and current to reach the aluminium substrate and continue growing the coating to greater thickness beyond what is produced by autopassivation. However, these same pores will later permit air or water to reach the substrate and initiate corrosion if not sealed. They are often filled with colored dyes and/or corrosion inhibitors before sealing. Because the dye is only superficial, the underlying oxide may continue to provide corrosion protection even if minor wear and scratches may break through the dyed layer.

Conditions such as electrolyte concentration, acidity, solution temperature, and current must be controlled to allow the formation of a consistent oxide layer. Harder, thicker films tend to be produced by more dilute solutions at lower temperatures with higher voltages and currents. The film thickness can range from under 0.5 micrometers for bright decorative work up to 150 micrometers for architectural applications.

Dual-finishing aluminium

Anodizing can be performed in combination with chromate conversion coating. Each process provides corrosion resistance, with anodizing offering a significant advantage when it comes to ruggedness or physical wear resistance. The reason for combining the processes can vary, however, the significant difference between anodizing and chromate conversion coating is the electrical conductivity of the films produced. Although both stable compounds, chromate conversion coating has a greatly increased electrical conductivity. Applications where this may be useful are varied, however, the issue of grounding components as part of a larger system is an obvious one.

The dual finishing process uses the best each process has to offer, anodizing with its hard wear resistance and chromate conversion coating with its electrical conductivity.

The process steps can typically involve chromate conversion coating the entire component, followed by a masking of the surface in areas where the chromate coating must remain intact. Beyond that, the chromate coating is then dissolved in unmasked areas. The component can then be anodized, with anodizing taking to the unmasked areas. The exact process will vary dependent on service provider, component geometry and required outcome.

5.6.1 Legislative Framework

As mentioned before, the policy for the aluminum production sector HZW, follows the same rules and directives as the previous cases examined. Therefore, the EU Waste Framework Directive (2009/98/EC) covers the management plan for aluminium production HZW and sets the rules for the basic management principles.

5.6.2 Aluminium coating processes best management practices

Anodizing is one of the more environmentally friendly metal finishing processes. With the exception of organic (aka integral color) anodizing, the by-products contain only small amounts of heavy metals, halogens, or volatile organic compounds. Integral color anodizing produces no VOCs, heavy metals, or halogens as all of the byproducts found in the effluent streams of other processes come from their dyes or plating materials.

The first step in dealing with wastewater is to produce less of it; this is the idea behind electrodialysis. Electrodialysis is a process of extending the life of the anodizing electrolyte by removing the aluminum ions from the bath. Electricity charges the ions that are then driven through an ionic sensitive membrane on their way to an oppositely charged electrode. The membrane picks up the aluminum and allows the acid electrolyte to pass through and continue back to the bath. The collected aluminum hydroxide is sludge, and the acid bath is then cleaned.

In another process called acid sorption, the exact opposite takes place. In acid sorption, ion exchange resins absorb the sulfuric acid while the metals pass by. The resins then release the acids in a water wash, and the metals are collected for disposal.

In another method, flocculating agents separate the aluminum from the electrolyte. These polymer additives combine with the aluminum hydroxide and congeal, creating a wooly mass that is skimmed away. The only equipment needed is the agents themselves—this makes it an attractive process to both large and small businesses.

In all of the above processes, heavy aluminum hydroxide sludge is left. Presses can squeeze out water, and sludge dryers further concentrate the sludge making it up to 75 percent solid. Small producers (less than 100 kilograms per month) are exempt from the authorities' guidelines in the disposal of hazardous waste and may take it to a general municipal landfill. Larger producers, though, must adhere to the regulations in the storage, transportation, and disposal of their waste.

Other Pollutants

Air pollution is a concern in the anodizing shop. In the anodizing bath, sulfuric acid fumes are released that can be hazardous not only to the air, but to employees in the plant. Local exhaust ventilation removes the fumes at the source point and a scrubber provides additional cleaning before release into the atmosphere. The concentration in the electrolyte bath may be only 10 to 20 percent, but long-term exposure causes permanent health problems if precautions are not taken. In the atmosphere, released sulfuric acid subsequently falls back to the ground as acid rain, which adversely affects flora, fauna, soils and surface waters. The Clean Air Act regulates the release of sulfuric acid into the atmosphere, not only controls its release, but also record keeping and reporting.

Besides the electrolyte bearing sludge, other wastes are generated in the anodizing process. The solvents and cleaners used in the pre-treating process, as well as the materials removed from the aluminum, must be collected and properly disposed of. After anodizing, there are also dyes and sealants that need additional disposal.

Hazardous waste contractors are an expensive way to deal with disposal, but save the anodizer from compliance errors that can be even more costly. Hazardous disposal contractor's services range from simple consulting to complete handling of the waste. Once in hand, the waste is recycled, incinerated, or taken to a landfill.

If sludge contains high enough levels of aluminum, it can be removed from sludge and sent off for use in the manufacturing of bricks and clays, cosmetics, and paper products. This process often proves unfeasible due either to the contaminants in the sludge or its low metal content per volume.

Incineration is another option for sludge disposal. It has the advantages of reducing both the volume and toxicity of the sludge, but is an expensive process.

5.7 Pharmaceutical industry

Pharmaceutical waste includes expired, unused, spilt and contaminated pharmaceutical products, prescribed and proprietary drugs, vaccines and sera that are no longer required, and, due to their chemical or biological nature, need to be disposed of carefully. The category also includes discarded items heavily contaminated during the handling of pharmaceuticals, such as bottles, vials and boxes containing pharmaceutical residues, gloves, masks and connecting tubing.

Genotoxic waste is highly hazardous and may have mutagenic (capable of inducing a genetic mutation), teratogenic (capable of causing defects in an embryo or fetus) or carcinogenic (cancer-causing) properties. The disposal of genotoxic waste raises serious safety problems, both inside hospitals and after disposal, and should be given special attention. Genotoxic waste may include certain cytostatic drugs, vomit, urine or faeces from patients treated with cytostatic drugs, chemicals and radioactive material.

Technically, genotoxic means toxic to the deoxyribonucleic acid (DNA); cytotoxic means toxic to the cell; cytostatic means suppressing the growth and multiplication of the cell; antineoplastic means inhibiting the development of abnormal tissue growth; and chemotherapeutic means the use of chemicals for treatment, including cancer therapy.

Cytotoxic (chemotherapeutic or antineoplastic) drugs, the principal substances in this category, have the ability to kill or stop the growth of certain living cells and are used in chemotherapy of cancer. They play an important role in the therapy of various neoplastic conditions but are also finding wider application as immunosuppressive agents in organ transplantation and in treating various diseases with an immunological basis. Cytotoxic drugs are most often used in specialized departments, such as oncology and radiotherapy units, whose main role is cancer treatment. Their use in other hospital departments and outside the hospital in clinics and elsewhere is also increasing.

Cytostatic drugs can be categorized as follows:

- alkylating agents: cause alkylation of DNA nucleotides, which leads to cross-linking and miscoding of the genetic stock;
- antimetabolites: inhibit the biosynthesis of nucleic acids in the cell;
- mitotic inhibitors: prevent cell replication.

Cytotoxic wastes are generated from several sources and can include the following:

- contaminated materials from drug preparation and administration, such as syringes, needles, gauzes, vials, packaging;
- outdated drugs, excess (leftover) solutions, drugs returned from the wards;

- urine, faeces and vomit from patients, which may contain potentially hazardous amounts of the administered cytostatic drugs or of their metabolites, and which should be considered genotoxic for at least 48 hours and sometimes up to 1 week after drug administration.

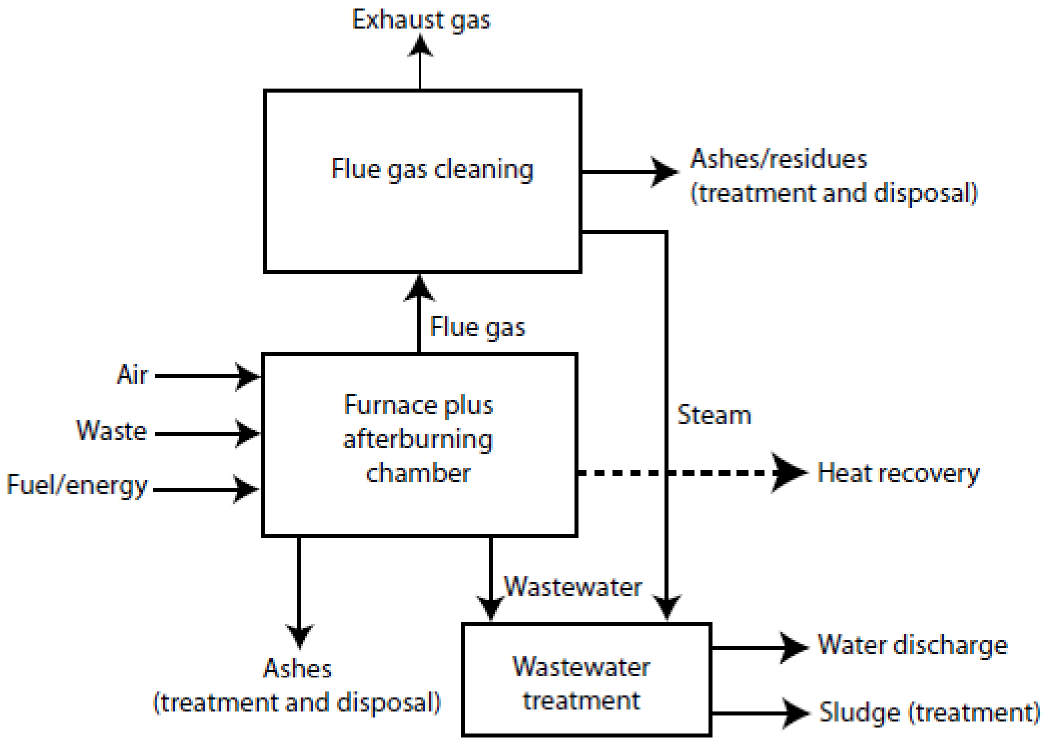
In specialized oncological hospitals, genotoxic waste (containing cytostatic or radioactive substances) may constitute as much as 1% of the total health-care wastes.

5.7.1 Legislative Framework

As mentioned before, the policy for pharmaceuticals sector HZW follows the same rules and directives as the previous cases examined, included in the EU Waste Framework Directive (2009/98/EC).

5.7.2 Pharmaceutical industry best environmental management practices

Incineration is a high-temperature, dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter and results in a significant reduction of waste volume and weight. High-heat thermal processes take place at temperatures from about 200 °C to more than 1000 °C. They involve the chemical and physical breakdown of organic material through the processes of combustion, pyrolysis or gasification. A disadvantage of these technologies is the release of combustion by-products into the atmosphere and the generation of residual ash. The combustion of health-care waste produces mainly gaseous emissions, including steam, carbon dioxide, nitrogen oxides, a range of volatile substances (e.g. metals, halogenic acids, products of incomplete combustion) and particulate matter, plus solid residues in the form of ashes. The figure below shows a simple schematic of the incineration process.



Source: Adapted by Jorge Emmanuel from UNEP (2006)

The Stockholm Convention guidance on best available techniques and best environmental practices states: “If medical waste is incinerated in conditions that do not constitute best available techniques or best environmental practices, there is potential for the release of PCDD [polychlorinated dibenzodioxins] and PCDF [polychlorinated dibenzofurans] in relatively high concentrations” (Secretariat of the Stockholm Convention, 2006).

The World Health Organization (WHO) has reviewed small-scale health-care incinerators and reported “significant problems regarding the siting, operation, maintenance and management of these incinerators” (Batterman, 2004). As a result of these and other concerns, together with the very high costs for modern incineration to meet best available technique (BAT) standards, the WHO report concluded that “small-scale incineration is viewed as a transitional means of disposal for health care waste” (Batterman, 2004).

Required waste characteristics

Incineration of waste is affordable and feasible only if the “heating” (or “calorific”) value of the waste reaches at least 2000 kcal/kg (8370 kJ/kg). While the value for hospital wastes containing high levels of plastics can exceed 4000 kcal/kg (16740 kJ/kg), some health-care waste may contain a high proportion of wet waste and have much lower calorific values. The basic characteristics necessary for incineration include:

- heating value above 2000 kcal/kg (8370 kJ/kg);
- calorific values within the regulatory and design requirements (e.g. the desired residence time, system operating temperature and excess air levels);
- content of combustible matter above 60%;
- content of non-combustible solids below 5%;
- content of non-combustible fines below 20%;
- moisture content below 30%.

Incineration requires no pretreatment, provided the following waste types are not included or are kept to an absolute minimum:

- pressurized gas containers;
- large amounts of reactive chemical waste;
- silver salts and photographic or radiographic wastes;
- halogenated materials such as polyvinyl chloride (PVC) plastics (waste and packaging of waste should not contain PVC material);
- waste containing mercury, cadmium and other heavy metals, such as broken thermometers, used batteries and lead-lined wooden panels;
- sealed ampoules or vials that may implode during the combustion process;
- radioactive materials;
- pharmaceuticals thermally stable in conditions below 1200 °C (e.g. 5-fluorouracil).

Energy recovery

Many modern large incineration facilities can reuse the heat generated from the combustion of waste, so energy recovery seems an attractive proposition. However, there are characteristics that need to be taken into consideration. Most health-care waste incinerators are too small for energy recovery to be effective. Whenever energy recovery is considered, it requires specialized advice on whether the proposition is technically and financially feasible for the local circumstances.

Types of incinerators for health-care waste

Incinerators range from extremely sophisticated, high-temperature operating plants to very basic combustion units. All types of incinerators, if operated properly, should eliminate pathogens from waste and reduce waste to a small volume of ash. Incineration equipment should be chosen on the basis of the available resources and the local situation, balancing the public health benefits of pathogen elimination against the technical requirements needed to avoid the health impacts of air or groundwater pollution from the by-products of waste combustion.

Three generic kinds of incineration technologies are commonly used for treating health-care waste:

- dual-chamber starved-air incinerators, which operate in the starved-air mode (below stochiometric conditions) in the primary chamber and are designed to burn infectious health-care waste;
- multiple chamber incinerators, including in-line incinerators and retort incinerators used for pathological waste, which operate in the excess-air mode (above stochiometric conditions);

- rotary kilns, normally capable of reaching temperatures that break down genotoxic substances and heat-resistant chemicals.

Starved-air incinerators

Starved-air incineration is a commonly used incineration process for health-care waste. The process is also known as controlled-air incineration, pyrolytic incineration, two-stage incineration or static hearth incineration. The combustion air used for incineration is less than stoichiometric (that is, the amount of oxygen is less than the ideal proportion needed for burning the carbon and hydrogen).

A starved-air incinerator comprises a primary chamber and a post-combustion secondary chamber. In the primary chamber, the waste is thermally decomposed through an oxygen-deficient, medium-temperature combustion process (800 to 900 °C), producing solid ashes and gases. The primary chamber includes a fuel burner, used to start the process. Waste residence time can vary from 1 to 4 hours, depending on the size of the installation. The gases produced in the primary chamber are burned at high temperature (ranging from 1100 to 1600 °C) in the secondary chamber, using an excess of air to minimize smoke, carbon monoxide and odours. If the temperature drops below 1100 °C (the minimum requirement specified in the European Union's Waste incineration directive 2000/76/EC), additional energy should be provided by a gas or fuel burner.

Larger pyrolytic incinerators (capacity >20 tonnes/day) are usually designed to function on a continuous basis. They are also capable of automatic operation, including loading of waste, removal of ashes and internal movement of burning waste.

Multiple chamber incinerators

Multiple chamber incinerators were more common in the past and are still used in some countries for pathological waste. There are two major types: in-line incinerators and retort incinerators. In-line incinerators are rectangular in design and have a large primary chamber with a moving grate, a secondary chamber to burn off volatile organic compounds in the flue gas, and additional chambers that force the gas to turn in different directions to remove particulate matter as ash residues.

Retort incinerators have a primary and a secondary chamber arranged in a "U" shape. Flue gas from the primary chamber (hearth) is generally passed under the primary chamber to add heat to the hearth. Both types of incinerators operate in the excess-air mode and use supplementary fuel to reach temperatures of around 800–1000 °C. These designs are not commonly used because of their high volumes of airborne emissions.

Rotary kilns

A rotary kiln has a rotating oven and a post-combustion chamber. They can be specifically designed to burn chemical wastes and may also be suitable as a large-scale regional health-care waste incinerator if appropriate temperatures and scrubbing (flue gas cleaning) equipment are used. The main characteristics of rotary kilns are:

- incineration temperatures between 900 and 1200 °C are possible;
- incinerator capacities up to 10 tonnes per hour are available;

- additional equipment and operation costs are high, as is energy consumption; the system also requires well-trained personnel.

The axis of a rotary kiln is inclined at a slight angle to the horizontal (3–5% slope). The kiln rotates 2–5 times per minute and is charged with waste at its upper end. Ashes are subsequently discharged at the bottom end. The gases produced in the kiln are heated to high temperatures to burn off gaseous organic compounds in the post-combustion chamber, and typically have a long residence time of two or more seconds.

Rotary kilns may operate continuously and are adaptable to a wide range of loading devices. Those designed to treat toxic wastes should preferably be operated by specialist waste-disposal agencies and located away from health-care facilities in industrial areas.

Small-scale incinerators

Small-scale incinerators are designed to meet an immediate need for public health protection where there is no access to more sophisticated technologies. This involves a compromise between the environmental impacts from controlled combustion and an overriding need to protect public health if the only alternative is indiscriminate dumping. These circumstances exist in many developing situations, and small-scale incineration can be a realistic response to an immediate requirement (Batterman, 2004). As far as possible, a small-scale facility should avoid burning PVC plastics and other chlorinated waste.

If small-scale incinerators are the only option available, the best practices possible should be used, to minimize operational impacts on the environment. Best practices in this context are (Batterman, 2004):

- effective waste reduction and segregation, ensuring only the smallest quantities of combustible waste types are incinerated;
- an engineered design with sufficient residence time and temperatures to minimize products of incomplete combustion;
- siting incinerators away from health-care buildings and residential areas or where food is grown;
- construction using detailed engineering plans and materials to minimize flaws that may lead to incomplete destruction of waste and premature failures of the incinerator;
- a clearly described method of operation to achieve the desired combustion conditions and emissions; for example, appropriate start-up and cool-down procedures, achievement and maintenance of a minimum temperature before waste is burned, use of appropriate loading/charging rates (both fuel and waste) to maintain appropriate temperatures, proper disposal of ash and equipment to safeguard workers;
- periodic maintenance to replace or repair defective components (including inspection, spare parts inventory and daily record keeping);
- improved training and management, possibly promoted by certification and inspection programmes for operators, the availability of an operating and maintenance manual, visible management oversight, and regular maintenance schedules.

In 2004, WHO commissioned a screening-level health risk assessment for exposure to dioxins and furans from small-scale incinerators. The study found that the expected practice with small-scale incinerators resulted in unacceptable cancer risks under medium usage (two hours per week) or higher (Batterman, 2004). The report concluded that small-scale incineration should be viewed as a transitional means of disposal for health-care waste. Single-chamber, drum and brick incinerators do not meet the BAT requirements of the Stockholm Convention guidelines (Secretariat of the Stockholm Convention, 2006).

Co-incineration

High-temperature incineration of chemical and pharmaceutical waste in industrial cement kilns or steel furnaces is practiced in some countries. Significant additional investments can be required to modify the facilities for safe handling and loading of medical wastes, and the machines are rarely equipped with filtration and clean-up equipment suitable for the pollutants generated. The Stockholm Convention guidelines list infectious medical wastes on a negative list of wastes not recommended for co-processing (Secretariat of the Stockholm Convention, 2006).

In some countries, it is permitted to incinerate health-care waste in a municipal solid waste incineration plant. The heating value of health-care waste can be higher than that of domestic refuse, and the introduction of relatively small quantities of health-care waste should not affect significantly the operation of municipal incinerators. Care must be taken with the handling and loading of the health-care wastes to avoid hazardous situations. Municipal incinerators are usually designed with an operating temperature of >850 °C.

Environmental control of incinerators

General principles

Incinerator emissions should comply with national standards and in accordance with the Stockholm Convention BAT and best environmental practices (BEP) guidance in those countries that have signed the convention. If the relevant authorities have not established such regulations, the BAT/BEP guidelines or international standards are examples of those that could be followed.

Incinerators require emission controls equipment to meet modern emission standards. It is determined that without emission controls dioxin concentrations in combustion gases were 93 to 710 times higher than the European Union legal limit (0.1 ng TEQ/m^3), depending on variations in the waste composition.

Flue (exhaust) gases from incinerators contain fly ash (particulates), heavy metals, dioxins, furans, thermally resistant organic compounds, and gases such as oxides of nitrogen, sulfur, carbon and hydrogen halides. The flue gases should be treated, and this should be done in at least two different stages:

- “de-dusting” to remove most of the fly ash
- washing with alkaline substances to remove hydrogen halides and sulfur oxides.

Flue gas treatment can be performed by wet, dry or semidry treatment, or a combination of these processes. The temperature of the combustion process has to be very closely controlled to avoid generating furans and dioxins, and the temperature in the flue gases should be cooled down rapidly to prevent dioxins and furans from reforming.

Stockholm Convention

The Stockholm Convention is a legally binding treaty with the goal of protecting human health and the environment from persistent organic pollutants. Under the convention, the countries party to the treaty are required to use the best available techniques for new incinerators. The Stockholm Convention's guidelines for best available techniques and best environmental practices limit the levels of dioxins and furans in air emissions to 0.1 ng I-TEQ/Nm^3 at 11% O_2. Moreover, dioxins in the wastewater of treatment plants treating effluents from any gas treatment scrubber effluents should be well below 0.1 ng I-TEQ per litre. In addition, the guidelines list primary and secondary measures to achieve the performance levels for removal of dioxins and furans. The primary measures are to:

- introduce the waste into the combustion chamber only at temperatures of ≥850 °C;
- install auxiliary burners for start-up and shut-down operations;
- avoid regular starting and stopping of the incineration process;
- avoid combustion temperatures below 850 °C and cold regions in the flue gas;
- control oxygen input depending on the heating value and consistency of feed material;
- maintain minimum residence time of two seconds above 850 °C in the secondary chamber after the last injection of air or at 1100 °C for wastes containing more than 1% halogenated organic substances (generally the case for health-care waste) and 6% O_2 by volume;
- maintain high turbulence of exhaust gases and reduction of excess air by injection of secondary air or recirculated flue gas, preheating of the air-streams or regulated air inflow;
- conduct on-line monitoring for combustion control (temperature, oxygen content, carbon monoxide, dust), and operation and regulation of the incinerator from a central console.

The secondary measures to further reduce dioxins and furans are an appropriate combination of dust-removal equipment and other techniques, such as catalytic oxidation, gas quenching and wet or (semi) dry adsorption systems. Furthermore, fly and bottom ash, as well as wastewater, should be treated appropriately. Carbon monoxide, oxygen in the flue gas, particulate matter, hydrogen chloride, sulfur dioxide, nitrogen oxides, hydrogen fluoride, airflows and temperatures, pressure drops and pH in the flue gas should be routinely monitored according to national laws and manufacturers' guidance.

Dust removal

The design of flue gas cleaning facilities assumes normal operation of an incinerator, especially temperature and air inputs. Depending on the type of incinerator, it is likely to produce between 25 and 30 kg of dust per tonne of waste (known as fly ash). For example, an incinerator of 20 tonnes/day capacity would need to be equipped with dust removal equipment to handle at least 600 kg/day (30 kg/tonne × 20 tonnes) of dust. The most common types of dust removal equipment used at incinerator plants are:

- cyclonic scrubbers
- fabric dust removers (commonly called "baghouse filters")
- electrostatic precipitators.

Flue gas emerges from the post-combustion chamber at about 800–1000 °C and must be cooled to 200–300 °C before entering the dust-removal equipment. This can be achieved in cooling towers, called quenching towers or baths, where the gas is cooled by water circulating in a closed system. (The water may subsequently be used for preheating waste or for other purposes.) A common method is the use of a boiler in which heat exchange takes place between the hot flue gas stream and boiler water. The hot flue gas stream is cooled, and boiler water is heated (the energy of this heated water or steam can be used for generating electricity or for other purposes). The flue gas can also be cooled by introducing fresh air, although this method is less efficient.

Removal of acids or alkalis

Three processes – wet, semi-dry and dry – are available for removing acids such as hydrofluoric acid (HF), hydrochloric acid (HCl), and sulfuric acid (H_2SO_4). In the wet process, gases are washed in a spraying tower with soda or lime solution, which also contributes to gas cooling and to the removal of very small particulates. In the semi-dry process (also known as semi-wet process), a lime suspension is injected into the gas column. Salts generated by the neutralization process have to be removed. In the dry process, lime powder is injected into the gas column, and the salts produced during the neutralization have to be removed. The wet process is the most efficient of these three options, but requires complex treatment of the resultant wastewater.

Wastewater from gas washing and quenching of ashes must undergo a chemical neutralization treatment before being discharged into a sewer. This treatment includes neutralization of acids and flocculation, and precipitation of insoluble salts.

Solid residues

Sludges from wastewater treatment and from cooling of fly ash should be considered as HZW. They may either be sent to a waste-disposal facility for hazardous chemicals, or be treated onsite by drying, followed by encapsulation. Solid ashes from health-care waste incineration (known as bottom ash) are often assumed to be less hazardous than fly ash and in the past have been reused in civil engineering works. Recently, growing debate about potential leakage of toxic substances from these ashes and possible pollution of groundwater has led some countries to require these ashes to be disposed of in landfills designed specifically for hazardous substances.

5. ADMINISTRATIVE SET-UP AND RESPONSIBILITES FOR AUTHORITIES DEALING WITH HAZARDOUS WASTE

The Administrative set-up, necessary to adequately address a critical sector, such as that of Hazardous Waste, is part of the overall Governance, covering not only the issue of waste, but also of the production and commerce of hazardous or potentially hazardous chemicals, pharmaceuticals, agrochemicals, etc., including health and overall risk issues to humans and the environment.

One of the most important stages in defining the appropriate administrative set-up in a country is the detailed mapping of all relevant authorities. Such a mapping needs to include a brief description of their competences/responsibilities. This may allow to identify if and where overlaps exist so that clarifications and arrangements become possible for obtaining synergies or allocation/designation of exclusive responsibilities, when needed. These arrangements could be achieved through dialogue and /or arbitration, using the internal governmental procedures.

During the presentation of the draft Task 4 and 5 report at the national consultation, it was requested that the proposal for an institutional set-up is made for Palestine based on experiences of other Mediterranean countries. The consultant selected the Greek experience as one which could be utilized, particularly in terms of mapping and describing the competences and responsibilities of each relevant agency and stakeholder. This is presented in part 5.1. and hopefully it may help the relevant Palestinian Authorities to prepare similar detailed lists useful for the needed dialogue and clarification of eventual overlaps.

The consultant has made in part 5.2 a broad mapping of the main Palestinian Authorities, mostly Ministries, involved in the management of HZW but it was not possible to obtain a verified detailed catalogue of all responsibilities and mandates given to each one of them.

5.1 The Greek example

The main entities that are involved in the implementation of the Greek national plan on solid waste management (under which HZW is included) with their main obligations, as they result from the applicable national and EU legislation, are described herewith. In **bold blue font** are the HZW specific sections:

Competent authorities and entities

Ministry of Production Reconstruction, Environment and Energy (YPAPEN)

- Establishment of a waste management policy.
- Preparation, proposition and establishment of a relevant legislative work (in cooperation with the relevant ministries) and issue of circulars for the implementation of the legislation in force.
- Development of the National Plan and, where appropriate, specific management plans and prevention programs (in cooperation with the relevant ministries).

- Monitoring the implementation of waste legislation, monitoring of the national waste management plan and the specific waste management plans.
- Collection and processing of data collection and processing of data on waste generation and management at national level.
- Opinion on the compatibility of regional and national plans.
- Notification of the European Commission on management plans and prevention programs as soon as they are adopted or revised.
- Notification of the European Commission through relevant reports for the progression of the implementation of the Directives and the achievement of the goals.
- Coverage of the country's relevant reporting obligations in relation to analyses published by European or International Organizations such as Eurostat and the Organization for Economic Co-operation and Development (OECD).
- Environmental licensing of Waste management projects and activities.
- Maintenance of inventory records of waste management bodies on National level.
- **Authorization of bodies for the collection and transport of hazardous waste at national level.**
- **Granting of "written consent for the transboundary transport" of hazardous waste**
- **Controls for cross-border waste shipment (co-operation with customs services of the Ministry of Finance).**
- **Inspections of waste management projects and activities (co-operation with Regions).**
- **Transmission to the European Commission of information on operators or companies which dispose of or use hazardous waste mainly on behalf of third parties and which may be part of the integrated network.**

Ministry of the Interior and Administrative Reconstruction (YPESDAN)

- Configuration and implementation of an institutional framework for the establishment and management of waste management bodies in co-operation with the HACCP.
- General Secretariat for Waste Management with responsibility for supervising and coordinating the activities of the Ministries of Interior, Environment and Economy, as well as all relevant Services and bodies (public and private) waste management.

Decentralized administration

- Environmental licensing of waste projects and waste management activities.
- **Licensing of bodies for the collection and transport of hazardous waste, within their spatial extent.**

Regional Authority

- Approval of regional plans (Regional Councils).
- Elaboration and implementation of regional plan in case of a failure of the authority after a relevant act of authentication.

- Submission of an annual report to the Ministry responsible for the implementation of the regional plan.
- Environmental Licensing of Waste Management Projects and Activities
- Inspections of waste management projects and activities

Greek Recycling Organization (supervised by the YPAPEN authority for alternative management flows)

- Design and implementation of alternative waste management and waste prevention policy - preparation for reuse.
- Approval and control of management systems - alternative management certificate version.
- Keeping a record of producers of products.
- Organizing an information system by informing the end users.
- Disclosure of the management systems business plans and their financial management.
- Planning of regular and extraordinary inspections of packaging managers / producers / other products and other entities involved in alternative management.
- Opinions on issues referred by the Minister.
- Coordination of the activity of public or private entities to design and implement alternative management programs.
- Recommendation for the submission of sanctions
- Suggestion for amendments to the institutional framework of alternative management.

Operator of solid waste management

- **Preparation and implementation of the regional plan as well as the design, implementation and operation studies of hazardous solid waste management projects specified in the regional plan. For waste streams that this is not feasible, undertake the owner or an authorized management body.**
- **Take measures for the rehabilitation, restoration and subsequent care of hazardous waste management facilities.**
- **Keeping a waste registry and management work.**
- **Submit an annual report with the data of the above registry to the relevant Decentralized Management.**

Municipalities

- Municipalities retain full and not exclusive responsibility for waste management from the prevention stage to the final disposal. In the context of local decentralized management plans, Municipalities are invited to design appropriate solutions for all management infrastructures in cooperation with (as far as possible) adjacent municipalities. In particular, and at least, the Municipalities undertake:
- **Collection and transport of hazardous waste.**
- Collection and transport of packaging waste
- Implementation of sorting systems at source.

- **Acceptance for collection and transport of hazardous waste, provided that there are relevant legal requirements.**
- Possibility of signing a contract with social economy bodies for screening at source and education

Other waste generators and operators

Waste management bodies

- Implementation of waste management operations (collection, storage, transport, recovery, disposal) following a permit (e.g. collection and transport permit, environmental permit (AEPO) and - if required - authorization of recovery and / or disposal facilities).
- Keeping of a waste register and management work.
- Submission of an annual, relevant report to the competent authorities.
- Refurbishment / rehabilitation of waste management facilities.

Producers (operators) or waste holders

- Delivery of waste to an authorized operator.
- Alternatively, he himself must secure the collection, transport, storing, recovery or disposal, in accordance with the provisions of the applicable legislation (acting as a waste management body).
- Keeping a waste register.
- Submission of an annual waste producer report to the competent authorities.

Alternative Management Systems (AMS)

- Organization of collection, transport, storage, recycling and recovery of alternative management flows.
- Achieving the quantified collection, recycling and recovery targets set.
- Collection - evaluation of quantitative and qualitative data and submission to EOAN.
- Submission to the EOAN of an annual result report on the implementation of the recycling programs they implement.

5.2 Proposed Institutional Setup

5.2.1 Establishment of a Palestinian Hazardous Waste Authority (PHWA)

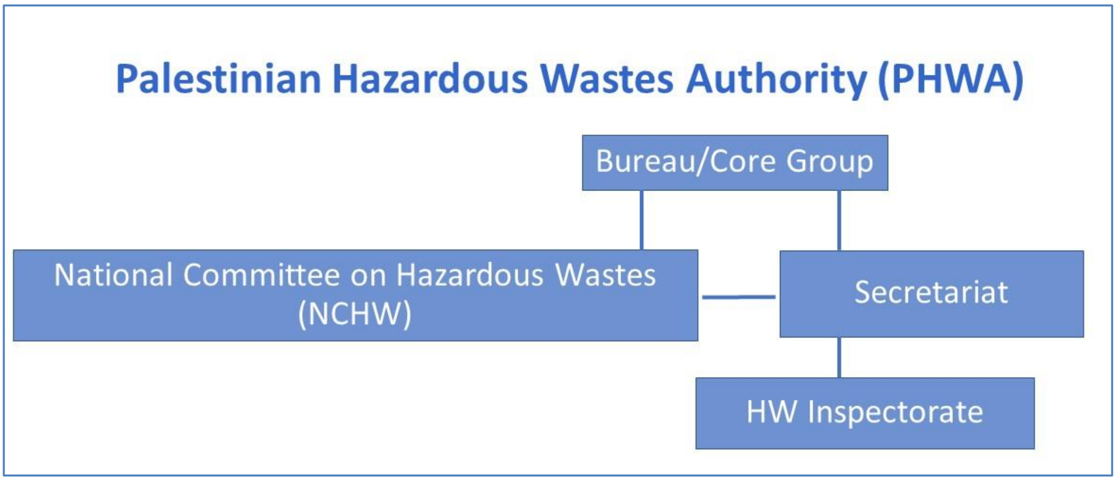
For the proper management of Hazardous Waste in Palestine, the establishment of a flexible **Palestinian Hazardous Waste Authority (PHWA)** is proposed.

The major Palestinian National Authorities, mostly Ministries, involved today in the management of Hazardous Wastes, are the following:

- EQA (Environment Quality Authority)
- MoH (Ministry of Health)
- MoLGT (Ministry of Local Government)
- MoNE (Ministry of National Economy)
- MoA (Ministry of Agriculture)
- MoE (Ministry of Finance)
- PSI (Palestine Standards Institution)
- PCBS (the Palestinian Central Bureau of Statistics)
- PENRA (the Palestinian Energy and Natural Resources Authority)
- MoT (Ministry of Transportation)
- PWA (Palestinian Water Authority)

All of them need to have a common place/platform to meet, exchange information and experiences and coordinate their proposals for policy development and enforcement, solve problems and address emerging issues in consultation with key stakeholders. Therefore, the establishment of a **National Committee of Hazardous Waste (NCHZW)** is proposed as an important component of an active Palestinian Hazardous Wastes Authority (PHWA). This Committee should include all the aforementioned Ministries and Agencies, as well as some basic stakeholders, from the producers, users, Academia and CSOs.

The National Committee of Hazardous Waste should meet at least twice per year to discuss on the Hazardous Waste Management Strategy and introduce, or amend when necessary, and review progress towards achieving its targets, possible challenges, etc.



Within the Committee (NCHZW) there should be a **Bureau /Core Group** with executive powers in order to propose legislation, monitor and report on Hazardous Waste compliance. This group should be supported by a permanent **Secretariat** that will act as an administrative office and connect the

Bureau/Core Group with the Committee and eventually additional stakeholders (industry, CSOs). The core group could comprise of all or some of the following (a governmental decision):

- EQA
- MoH
- MoLGT
- MoNE
- MoA
- MoE

In order to achieve coherence among the different stakeholders' responsibilities, a well-thought plan of allocated roles should be established. The preliminary allocation of responsibilities of the Governmental Members of the NHWC, in terms of regulatory and operational issues is depicted in the following table **('Roles/tasks of the different hazardous waste stakeholders')** reflecting also, to a large extent, the current situation. The harmonization and eventual simplification of overlapping mandates is an important step in improving the governance of hazardous waste management.

	Task	EQA	MoH	MoLG	MoNE	MoA	MoF	PSI	PCBS	PENRA	MoT	PWA
Regulatory	Development of HZW by-law	√	A	A	A	A	A	A			√	A
	Reinforcement of HZW department	√			A	A						A
	Environmental inspection	√	√		A	M						
	Regulation of the rules for handling medical waste	M	√*	√		A						
	Control over agricultural chemicals	M		A		√						
	Monitoring of import/export of HZ material and waste	M			√	√		A		A	M	
	Permitting import/export of HZ material	√			A	√		A		M		
	Issuing list of HZ material specification	A	M		A			√				
	Issuing a list of HZ material allowed/*forbidden	√	A		A	A				A		
	Preparation of MSDS	√	A		√	A		A				
	Monitoring HZ material movement	√	M	√	M	√	M					
	Fund allocations for HZW management	√	√	√	√	√	√					
	Key role in NHWMP	√	√	√	√	√	√				√	√
	Specification of Tech requirements of HZW vehicles	M	M	√				√			√	
Operational Issues	Collection and segregation at source	M	M	√	M	M		A			C	
	How dealing with HZW	M	A	√		A	A	A	A	A	C	
	Amount of HZW	√	√	√	√	√			√		C	C
	HZW cell for pesticides and fertilizers	M	M			√					C	

√: Main responsibility: means filling forms and following up any incident /accident/ actions
M: Monitoring: means checking out filled forms and comparing them to actual case
A: Technical assistance: means providing all technical assistance needed to create a law, regulation or guidelines
C: Copy: means a copy of any filled forms must be sent to the stakeholders for their records

5.2.2 Regulatory Enforcement and Inspection

Regulation is a key tool for achieving the social, economic and environmental policy objectives of a State. Governments have a broad range of regulatory schemes reflecting the complex and diverse needs of their citizens, communities and economy. Ensuring effective compliance with rules and regulations is an important factor in creating a well-functioning society and trust in the governance scheme. If not properly enforced, regulations cannot effectively achieve the goals intended by the legislators. Regulatory enforcement is therefore a major element in safeguarding health and safety, protecting the environment, securing stable state revenues, ensuring social welfare and delivering other essential public goals.

Inspections are the most visible and important among regulatory enforcement activities. Regulatory enforcement schemes and inspections are relatively new and understudied elements of regulatory policies that have been gaining importance recently. The major challenge for governments is to develop and apply enforcement strategies that deliver the best possible outcomes by achieving the highest possible levels of compliance, going in parallel with the acceptance and support of the public, while keeping regulatory costs and administrative burdens as low as possible.

In seeking to determine whether businesses and individuals are compliant with their legal requirements, the relevant authorities can undertake a variety of different inspections, checks, investigations, etc. It is important to stress that the type of activity undertaken will vary according to the nature of the obligation. The way specific terms are used internationally, such as ‘inspection’, varies and it is therefore important not to assume the content of a particular activity, unless it is clearly defined/specified. Furthermore, providing some legal and financial incentives to the manufacturers, importers/distributors and /or waste recyclers/removers highly encourages compliance to regulation.

‘Inspection’ in many cases is assumed to include a visit to a site or individual, but this is not always the case. Indeed, document checking (including on-line) can be referred to as ‘inspection’. Intelligence-led approaches contrast by being investigative in character, gathering intelligence, information, etc. They may involve site visits, but in most cases, they are not considered as “inspection” but as evidence gathering or “complementary” controls. In this respect and as indicated above, environmental inspection in Palestine could be implemented by the following stakeholders:

- EQA
- MoH
- MoLG

Accordingly, the MoNE could have a role of providing technical assistance in the regulatory part. The MoA could also act as a complementary monitoring authority, to compare filled forms with actual cases. It can be seen, therefore, that institutional contexts for different aspects of control of legislation vary significantly.

Some constraints are identified with regard to national control bodies, but shortcomings in institutional settings are found most commonly at sub-national local level where control functions are highly devolved. Of course, local context and community involvement are important, but localized control has frequently problems of capacity and of interaction with national objectives. Furthermore, local enforcement bodies often have to address many different issues at the same time, with limited human resources, and these can present competing priorities not necessarily consistent with the priorities established in national law. Furthermore, where the emphasis is on local control activity, it is often difficult for national bodies to have a clear picture of the levels of control activity and to understand if it is effective. Finally, local institutions have the potential to be more strongly influenced by local political interests, while there is also a concern related to harmonized implementation and controls throughout the country.

In this respect, taking into account the aforementioned, for a relatively small country like Palestine, and at least for an initial period of several years, it is proposed that the control/inspection responsibilities are centralized and the Hazardous Waste Inspectorate is directly attached to the Bureau of the National Hazardous Waste Committee, facilitated by the Secretariat (see indicative organigramme). In the inspectorate, it is possible that inspectors from different related Ministries are appointed, eventually carrying out joint side visits/controls, related to more than one aspects or themes.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on the comments and findings from all sections of the report, the following conclusions and recommendations can be drawn:

The current state of management of Hazardous Waste (HZW) in Palestine is rather poor and cannot be considered as satisfactory. Most of the HZW is not separated from municipal streams, although several efforts have been made. Of importance could be considered the recently issued (2018) “Hazardous Waste Management Bylaws’, accepted by the Cabinet. The dynamic that these bylaws create should be enhanced and used for further improvement, completion and implementation of the HZWMP and for the mobilisation of all relevant industrial sectors and HZW handlers/managers, following a series of concrete measures/interventions mentioned herewith.

In parallel, it has become obvious from the analysis of the seven industrial sectors reviewed, that there are considerable opportunities to drastically reduce and treat a series of HZW streams in Palestine by implementing non-expensive good practices such as those described in the present document and very briefly summarised in this part of the conclusions and recommendations

Assumptions and studies that were conducted several years ago have been the basis of the report. These data may be outdated and for the purpose of proper updating, complementary information is needed based on new data about the current situation in Palestine. Special attention should be drawn to those related to the inventory data and the HZW classification.

As Palestine does not have in place, at present, adequate facilities to dispose hazardous waste in a manner which will safeguard public health and the environment, it is recommended for the Authorities to discuss in depth with the various sectors involved, to define and agree which best practices could be adopted and implemented in the country, by taking into account the relevant costs and eventually providing some legal and financial incentives to the manufacturers, importers/distributors and /or waste recyclers/removers. Then, there should be a revisit/ restudy of the prepared forms and guidelines in order to make sure that these forms comply with the Basel Convention requirements in making a final decision whether to consent or reject a proposed trans-boundary movement of waste.

Meetings should be conducted with all stakeholders (further to those carried out during the SWIM-H2020 SM missions in February and November 2018) to discuss:

(1) which activities from the implementation programs suggested in the report are already carried out

(2) the reasons why other suggested activities are not commencing

(3) suggest a timetable for the implementation of further selected proposals.

The Gap Analysis, in the format of a Table (see Table 5.1), sums up all major gaps identified within the Palestinian National Plan for Hazardous Waste Management, and the recommended actions to be implemented. In section 6, a summary is given of good practices related to the seven sectors reviewed. Many of them can be easily adopted and implemented in Palestine.

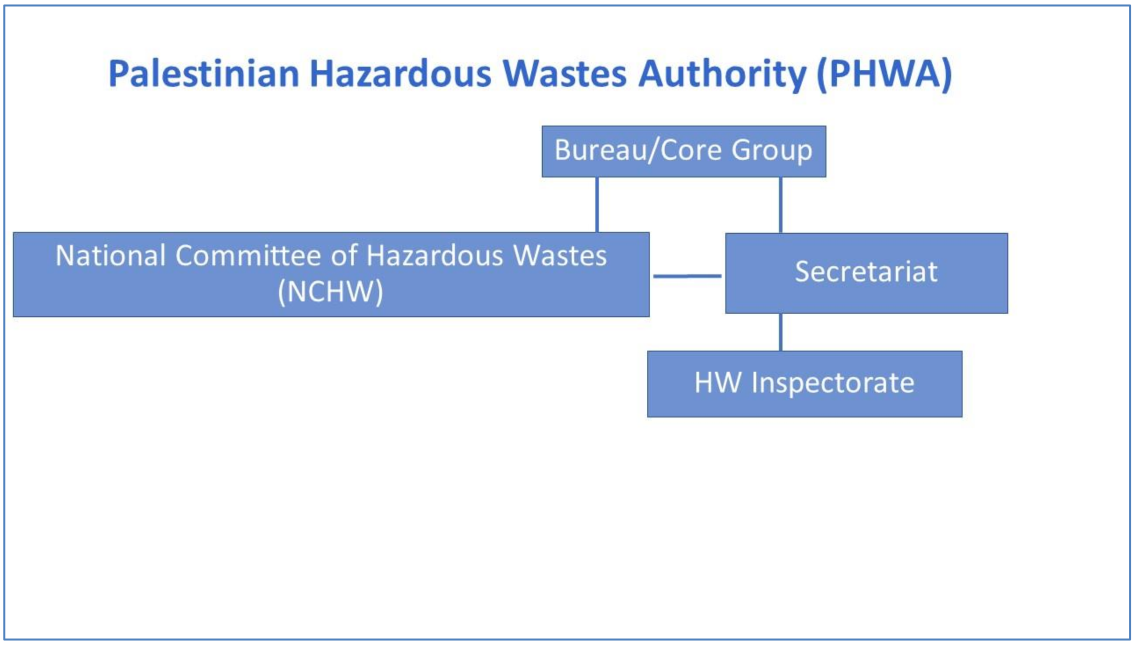
Table 5.1: Gap analysis and actions to be implemented

HZW management step	Existing Gap	Actions needed
Generation and characterization	1. The generation of HZW was based on several assumptions. 2. Not all premises producing HW were visited. 3. Generated HZW from Gaza Strip were estimated but not measured. 4. Still there is no approved HZW lists	• Assumptions should be minimized by well-prepared time frame field visits to HZW generators using Basel convention guidelines • Make sure that HZW generators have a bookkeeping system of all generated HZW. Therefore, a scheduled plan for HZW generators visit should be carefully planned taking into consideration the capacity building needs of inspection departments from all stakeholders. • Carry out site visits to Gaza strip's HZW generators and record the quality and quantity of HZW. • Adopt the Basel convention HZW list (by the time of preparation of this report, the list is already adopted by national legislation) • Carry out HZW inventory on regular basis based on the HZW list
On site storage	The NHWM report stated that all HZW generators claim that store their HZW in proper containers	• A systematic comparison between HZW bookkeeping records and physical inspection of stored HZW should be carried out • National programs should be carried out to educate/inform HZW generators of benefits gained from proper storage and possibility of applying 3R's concept to minimize on site storage. • A training program should be arranged for educating HZW generators of the best onsite HZW management practices
HZW transport	1. No proper specifications for HZW transport vehicle are assigned 2. No proper regulations are mentioned in the NHZWMP for internal and transboundary movement of HZW. (Until the start of this assignment (2017), the HWM bylaw was not approved by the cabinet	• More implementation programs should be proposed to educate HZW generators about the Palestinian regulations of HZW. • Revisit all forms and guidance prepared to the national competent authority in making a decision whether to consent or reject a proposed trans-boundary movement of waste subject to the Basel convention. Check their consistency with the regulations outlined in the recently issued Hazardous waste management bylaw which was approved by the (cabinet in 2018). • Prepare an implementation program to educate stakeholders of how to use HZW transportation forms and procedures. • A contingency plan should be design of how to deal with HZW emergency cases in terms of illegal transportation or incidents during transportation in cooperation of civil defense.
HZW disposal	No HZW indicators exist	In response to the need for monitoring the performance of HZW

HZW management step	Existing Gap	Actions needed
		management, sets of indicators have to be created within larger scope of environmental performance indicators for industry. The HZW indicators should address three themes: • compliance to regulations, • HZW generation, and management • cleaner production. Opportunities for use of indicators particularly as a decision – making support tool and expected challenges facing their applications should be outlined
Implementation programs	No fiches exist	There should be fiches for all suggested implementation programs taking into consideration all resources available by public bodies, private enterprises and stakeholders. The cooperation of all stakeholders is essential for the success of implementing the NHWMP to comply with Basel Convention
Monitoring of HZW	No fiche exists for the infrastructure of establishing HZW audit office.	There should be a project fiche for the establishment of HZW management audit office that will regularly monitor the lifecycle of HZW of certain industries and record HZW indicators
Stakeholders	Essential stakeholders are missing	Three key player stakeholders need to be added to the list and their responsibilities towards HZW management should be identified. These players are: PSI, PCBS and PENRA Redistribute all responsibilities between all stakeholders taking care of their human capacity.
Education and Public awareness	No specific Education for Sustainable Development on HZW	ESD in all educational levels to inform on impact of HZW and on how to avoid and contribute to their reduction.

Based on the above, there is a need to review the role and duties of agencies and stakeholders as defined in the implementation programs and amend or reallocate some of their responsibilities based on their capacities and available means.

As suggested, in section 5 of the present document, the establishment of a Palestinian Hazardous Waste Authority is proposed, within which a National Committee on Hazardous Waste operates, coordinated by a Bureau/Core Group facilitated by a permanent Secretariat. An inspectorate will also be attached as shown in the diagramme.



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6. SUMMARY OF RECOMMENDED GOOD PRACTICES ON THE SEVEN KEY INDUSTRIAL SECTORS

It is of utmost importance that the Hazardous Waste of the following sectors are not mixed but segregated from municipal solid waste and dealt with separately using some of the good practices mentioned herewith and/or safely exported, if no other proper solution can be found in Palestine.

7.1 Olive oil mills

There is a need for a normative, that imposes a common policy for Oil Mill Wastewater management for all olive producing countries in the Mediterranean region. All suggestions must be in tune with the latest legislation, therefore the ministries should accept the current set of BATs (Best Available Techniques) as proposed by the European Union.

Since Oil Mill Wastewater is a strong pollutant but simultaneously a source of valuable components, various methods of best practices could be implemented. These methods include, in terms of dealing with the pollutants, detoxification processes such as aerobic and anaerobic procedures. In terms of reuse, methods proposed are further processing and production of fertilizers and compost.

7.2 Treatment of used oils

Used oils are a major source of hazardous waste in Palestine. The environmental impact of discharged used mineral oil depends on its physical and chemical properties, the amounts disposed of in an uncontrolled way, the features of the underlying soil and local hydrological characteristics. Disposing of used motor oil by pouring it into storm or sewage drains, dumping it onto the ground, or disposing of it with household waste may create significant risks to human health and the environment and should be stopped urgently. There is presently no system in place by the authorities or the private sector for the collection and processing of used engine oils and components. Most of the oily vehicle components are currently burnt and the rest is spilled irregularly.

The proposed methodology for best management of used oil handling and treatment is firstly the treatment applied mainly to recover materials from the used oils (recycling) and secondly the treatment primarily aimed at producing material to be used as fuel. The recycling process includes removal of impurities and additives. For the oil recovery, processes as de-watering, de-fueling and removal of asphaltic residues are proposed as well.

7.3 Bitumen production & handling and Asphalt Reuse

Good practices related to bitumen, refer to two aspects: (1) handling, storage, loading and unloading bitumen in liquid form. This should be done carefully to avoid fires through autoignition. This is done in specially designed tanks, equipped with nitrogen blanketing and pressure/vacuum safety values; (2) the recycling of asphalt which allows reuse of bitumen and the aggregates contained in it.

Asphalt pavement is the most recycled material in the EU. Not only recyclable, it can be reused over and over again in new asphalt pavement mixes. The old bitumen binder is reactivated, replacing part of the new bitumen required in a new mix, just as the old aggregate becomes part of the aggregate content of the new pavement. Several million tons of asphalt pavement is reclaimed each year, and over 99% of that total is reused or recycled. Asphalt, when applied becomes hard and is virtually inert. No materials are leached from the pavement itself (because it is waterproof). In fact, a number of drinking water reservoirs and fish hatcheries are lined with asphalt. Emissions and leachate from RAP stockpiles have been found to be practically nonexistent. In addition to reclaimed asphalt pavements, materials from other industries are routinely recycled into asphalt pavements, including rubber from used tires, glass, asphalt roofing shingles, and blast furnace slag. Recycling of asphalt pavement and asphalt roofing shingles could conserve several million barrels of liquid bitumen.

7.4 Coating of furniture and wood material

Wooden furniture manufacturing involves preserving wood, as well as applying paint. Different oil-based and solvent-based paints are commonly used for furniture. Many of these are hazardous, such as formaldehyde and glue plant sludge.

Several techniques can be used by the sector, complying with best management practices. These practices comprise of minimization of raw material consumption, replacement of more harmful substances with less harmful ones to the environment. Furthermore, applying different painting techniques and equipment such as curtain coating, flooding or High-Volume Low-Pressure Spraying, can result in less hazardous waste production.

7.5 Dyes and pigments

The paint manufacturing process involves the mixing of different agents such as pigments, solvents and a wide range of different agents (anti caking, etc, filling materials, dyes, acrylics and long alkyds. A range of hazardous substances are used in the processes such as ethyl benzene and similar organic compounds, various acids, metals, acrylates, hazardous isomers, and alcohols, as well as particulates. These wastes are generated from the transfer of raw materials from one processing area to another. This includes paint and varnish, halogenated solvents, sludge (aqueous and other) from paint or varnish removal containing halogenated solvents, adhesives and resins.

The effluent treatment comprises of neutralization, flocculation, coagulation, settling, carbon adsorption, detoxification of organics by oxidation (using ultraviolet systems or peroxide solutions), and biological treatment. Solid wastes of such processes are in general incinerated.

7.6 Aluminium coating processes

Anodizing is an electrochemical process that converts the metal surface into a decorative, durable, corrosion-resistant, anodic oxide finish. The anodized aluminium layer is grown by passing a direct current through an electrolytic solution, with the aluminium object serving as the anode (the positive electrode). Anodizing is one of the relatively more environmentally friendly metal finishing processes. With the exception of organic (aka integral color) anodizing, the by-products contain only small amounts of heavy metals, halogens, or volatile organic compounds. In integral color anodizing, hazardous wastes associated to the byproducts found in the effluent streams of other processes coming from dyes or plating materials are avoided.

It is well known that the first step in dealing with wastewater is to produce less of it; this is also the idea behind electrodialysis. In another process called acid sorption, the exact opposite takes place. In acid sorption, ion exchange resins absorb the sulfuric acid while the metals pass by. The resins then release the acids in a water wash, and the metals are collected for disposal. In another method, flocculating agents separate the aluminum from the electrolyte. The only equipment needed is the agents themselves—this makes it an attractive process to both large and small businesses. In all of the above processes, heavy aluminum hydroxide sludge is left. Presses can squeeze out water, and sludge dryers further concentrate the sludge making it up to 75 percent solid.

Air pollution is also a concern in the anodizing shop. In the anodizing bath, sulfuric acid fumes are released that can be hazardous not only to the air, but to employees in the plant. Local exhaust ventilation removes the fumes at the source point and a scrubber provides additional cleaning before release into the atmosphere. EU legislation provides for control of the release of sulfuric acid into the atmosphere, and also for record keeping and reporting.

7.7 Pharmaceutical industry

Pharmaceutical waste can be minimized by good inventory control or a “just-in-time” inventory strategy; by purchasing drugs in the dosages routinely administered; by monitoring expiration dates so that existing stock is used before newly arrived supplies (also known as good “stock rotation”); by replacing prepackaged unit dose liquids with patient-specific oral doses; and other good management practices of the sectors.

Before treatment, pharmaceutical waste should be labelled and sorted using proper personal protective equipment. Pharmaceutical waste can be sorted according to dosage form (solids, semi-solids, powders, liquids or aerosols) or by active ingredient, depending on the treatment options available. Special consideration is needed for controlled substances (e.g. narcotics), anti-infective drugs, antineoplastic and cytotoxic drugs, and disinfectants.

Several options exist for small quantities of pharmaceutical waste:

- return of expired pharmaceuticals to the manufacturer or donor ;
- encapsulation and burial in a sanitary landfill;
- chemical decomposition in accordance with the manufacturer’s recommendations if chemical expertise and materials are available;
- dilution in large amounts of water and discharge into a sewer for moderate quantities of relatively mild liquid or semi-liquid pharmaceuticals, such as solutions containing vitamins, cough syrups, intravenous solutions and eye drops.

Antibiotics or cytotoxic drugs should not be discharged into municipal sewers or watercourses.

For large quantities of pharmaceutical waste, the options available include:

- encapsulation and burial in a sanitary landfill;
- incineration in kilns equipped with pollution-control devices designed for industrial waste that operate at high temperatures;

- dilution and sewer discharge for relatively harmless liquids such as intravenous fluids (salts, amino acids, glucose).

Some emerging technologies include large-scale ozonation and decomposition using iron-tetraamidomacrocyclic ligand (Fe-TAML) peroxide catalysis. These technologies should be evaluated carefully, because many do not have an established record for treating health-care-related pharmaceutical waste.

7. CITATION

1) Dr. Kostas Chartzoulakis, Alternative technologies and policies for olive mill waste management in MED countries, SWIM and Horizon 2020 SM, 4-7/12/2017

2) Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas, JOINT RESEARCH CENTRE, European IPPC Bureau, 2015

3) Raising Standards, Making Defra's hazardous waste strategy a reality, Environmental Services Association, January 2013

4) Best Available Techniques (BAT) Reference Document on Surface Treatment using Organic Solvents, JOINT RESEARCH CENTRE, European IPPC Bureau, October 2017Best Available Techniques (BAT) Reference Document for Waste Treatment, JOINT RESEARCH CENTRE, European IPPC Bureau, December 2015

5) Best Available Techniques (BAT) Reference Document in the Food, Drink and Milk Industries, JOINT RESEARCH CENTRE, European IPPC Bureau, January 2017

6) Best Available Techniques (BAT) Reference Document for Waste Treatment, JOINT RESEARCH CENTRE, European IPPC Bureau, December 2015

7) Safe Management of wastes from health-care activities, second edition, World Health Organization, 2014

8) Best Available Techniques (BAT) Reference Document for the manufacture of Organic Fine Chemicals, European Commission, European IPPC Bureau, August 2016

9) Hellenic National Hazardous Waste Management Plan, Ministry of Environment and Energy, December 2016

10) National Waste Management Review of Sweden, Germany, Denmark, Finland, RECO Baltic 21 Tech Project, IVL Report E006, 2012

11) Solid Waste Management in Bulgaria, Croatia, Poland and Romania, A cross-country analysis of sector challenges towards EU harmonization, Document of the World Bank Sustainable Development Department Europe and Central Asia Region (ECSSD), Report No. 60078-ECA, April 2011

12) The Used Oil Management Handbook, Guidance for Used Oil Handlers, Alabama Department of Environmental Management, August 2012

13) The Used Oil Recycling Handbook, Guidance for Used Oil Handlers, Texas Commission on Environmental Quality, May 2011

14) Pavements, Federal Highway Administration, US Department of Transportation, June 2017

15) M. Niaounakis and C.P. Halvadakis " Olive Processing Waste Management-Literature Review and Patent Survey", Waste Management Series No 5, Elsevier, 2nd Ed. 2006.

16) Stuart Batterman, Assessment of Small-Scale Incinerators for Health Care Waste, February 2004

8. ANNEX

Task 5 of the activity EFH-PS-4 of the SWIM H2020 SM Project

Consultation on the review and development of the national institutional setup for Hazardous Waste Management

Ramallah, 27 November 2018

Agenda and Key Points from the discussion

(Light Lunch directly after the Country Meeting)

13.00-13.15: Welcome

3.15-13.45: Presentation of the draft document

13.45-14.45: Facilitated discussion with suggested inputs/adaptations

14.45-15.00: Conclusions and wrap up

Key issues discussed:

- Presentation of the draft document on institutional setup with the outcome of the Gap Analysis as well as Compendium of Best Management Practices
- Discussion on the proposed roles of the different hazardous waste stakeholders
- Discussion on the Compendium of best management practices
- Discussion on waste management hierarchy depicting that the hierarchical order should be prevention, re-use, recycle, recovery, disposal
- Presentation of the Industrial Emission Directive that is applied throughout Europe for the purposes of minimizing the environmental impact of industrial activities
- Discussion on the European Waste Framework Directive
- Discussion on the link of Best Available Techniques and the EU Directives
- Discussion on why pesticides where not included in the list
- Discussion on the Palestinian limitation of authority and on the legal provisions relevant to waste management and treatment

- Discussion on a By-law document that was recently approved by the authority and concerns medical waste
- A brief description on the way hazardous waste is handled currently was given by several participants. Specific examples were given for medical and pharmaceutical waste as well as for municipal waste
- Special notice was given to the case of incineration of waste and the fact that this is not applied in Palestine.

Outputs:

- The section of the compendium and institutional setup, that is relevant to asphalt reuse should be amended. The text included information on construction and demolition waste rather than asphalt production that is more relevant to the case of Palestine.
- The secondary aluminium production, that was included in the institutional setup should be amended. The aluminum coating process is of greater interest to the Palestinian Authority.
- Pharmaceutical waste should also be included in the list of processes. Relevant Best Available Techniques for the abatement of waste should be included in the report.
- A more specific proposal on the institutional setup of the Palestinian Authority, as regards the hazardous waste management should be included in the report.

EFH-PS-4 Support for hazardous waste management
27 November 2018, Ramallah, Palestine

COUNTRY	TYPE OF INSTITUTION (please use the options provided*)	TITLE (Mr/Ms)	FIRST NAME	LAST NAME	POSITION/ FUNCTION	ORGANISATION/ INSTITUTION
PALESTINE	MINISTRY REPRESENTATIVES	Mr.	Talib	IHMIED	Director of Environmental Monitoring & Inspection Department	Environment Quality Authority (EQA)
PALESTINE	MINISTRY REPRESENTATIVES	Mr.	Yaser	ABU SHANAB	Acting General Director of Environmental Protection	Environment Quality Authority (EQA)
PALESTINE	MINISTRY REPRESENTATIVES	Ms.	Ruba	ARMAN	Hazardous Waste sector	Environment Quality Authority (EQA)
PALESTINE	ACADEMIA AND RESEARCH INSTITUTES	Ms.	Safieh	IBRAHIM	Head of Solid Waste Division	Palestinian Central Bureau of Statistics (PCBS)
PALESTINE	MINISTRY REPRESENTATIVES	Ms.	Kahramana	AL-KELANI	Directory of International Relations	Environment Quality Authority (EQA)
PALESTINE	MINISTRY REPRESENTATIVES	Mr.	Suleiman	ABU MFAREH	Director General	Ministry of Local Government (MOLG)
PALESTINE	MINISTRY REPRESENTATIVES	Mr.	Mahmoud	OTHMAN		Ministry of Health (MoH)
PALESTINE	MINISTRY REPRESENTATIVES	Mr.	Zeyad	FADEL	Director of National Industry	Ministry of National Economy (MONE)
PALESTINE	MINISTRY REPRESENTATIVES	Mr.	Amjad	KHARRAZ	Director	Environment Quality Authority (EQA)
PALESTINE	MINISTRY REPRESENTATIVES	Ms.	Doa	ABDALLAH	Environmental Inspector	Environment Quality Authority (EQA)
PALESTINE	MINISTRY REPRESENTATIVES	Mr.	Bader	ALHAWAMDEH	General Director of PPIS	Ministry of Agriculture (MoA)
PALESTINE	MINISTRY REPRESENTATIVES	Mr.	Ahmad	ABUTHAHER	Director General for Projects & International Relations	Environment Quality Authority (EQA) / H2020 Focal Point
GREECE	INTERNATIONAL ORGANISATIONS AND PROGRAMMES	Prof.	Michael	SCOULLOS	Team Leader	SWIM-H2020 SM
GREECE	INTERNATIONAL ORGANISATIONS AND PROGRAMMES	Ms.	Anastasia	RONIOTES	Project Expert	SWIM-H2020 SM
GREECE	INTERNATIONAL ORGANISATIONS AND PROGRAMMES	Mr.	Stavros	VLACHOS	Consultant / Project Expert	Enviromentrics / SWIM-H2020 SM