Sewage Sludge management with emphasis on its use in Agriculture

Based on the knowledge generated by the Peer-to-Peer exchange on Sludge Management, focusing on possibilities and conditions for utilization/different applications (P2P-2)

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V1	Sewage Sludge management with emphasis on its use in Agriculture Based on the knowledge generated by the Peer-to-Peer exchange on Sludge Management, focusing on possibilities and conditions for utilization/different applications (P2P-2)	Simos Malamis	Prof. Michael Scoullos

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1. Introduction

1.1 The purpose

This document serves as a guide for the development of appropriate legislation regarding sustainable sewage sludge management destined for use in agriculture. The purpose of this document is not to provide a solid legislative framework nor to provide a detailed analysis of sewage sludge management. Instead it provides a basic roadmap that will facilitate the subsequent implementation of a legislative framework in Mediterranean countries with respect to sewage sludge application in agriculture.

This document considers sewage sludge produced from municipal and domestic wastewater treatment plants (WWTPs) as well as industrial sludge from specific industrial activities. It does not include fecal sludge or sludge produced from industrial wastewater treatment other than those industries which are explicitly specified. Furthermore, it considers the management of dewatered sewage sludge once the typical processes of thickening, anaerobic digestion and dewatering have been implemented.

The document considers the necessary conditions, parameters to be examined and criteria to be met in order to make sure that the produced sludge could be used in agriculture in a safe way. Alternative uses are also briefly discussed.

1.2 The discussions with the peers

The present document was developed within the framework of the Sustainable Water Integrated Management and Horizon 2020 Support Mechanism (SWIM-H2020 SM). It is the outcome of the peer-to-peer communication which took place with key experts from Lebanon, Morocco and Palestine (P2P-2) as well as the regional workshop based on a study visit organized in Athens, Greece on sewage sludge management on 25-27 June 2018.

Peer-to-peer activities were implemented between Simos Malamis (the Coach) and Rami Nassif and Sabine Ghosn from Lebanon, Malika El Bayoudi from Morocco and Amjad Kharraz from Palestine. In the case of Lebanon and Morocco the peer-to-peer meetings were implementing via Teleconference, while in the case of Palestine via email exchange.

During the sludge workshop organized in Athens, a meeting took place between the coach and the appointed peers to discuss about their interests and challenges to be addressed regarding sewage sludge management. The Lebanese peer mentioned that in Lebanon the legislative framework is currently insufficient to address sewage sludge management and that Lebanon needs to consider the existing international standards. Agricultural use of sewage sludge is very important for the country and successful pilot activities could help support this. The Palestinian peer mentioned that their biggest challenge is the high moisture level of sewage sludge which limits the potential valorisation. Activities need to be implemented to divert sewage sludge away from landfill and towards agricultural utilization

(Abu Ghosh et al., 2017). Effective legislation is also lacking here to allow high quality compost to be applied to land. The Moroccan peer stressed the fact that in Morocco there is a lot of bureaucracy involved in sewage sludge management which is a significant barrier to sludge valorisation. Moroccans are very much interested to learn about successful cases of sewage sludge use in agriculture. The meeting was concluded with reference to the peer-to-peer activities which will take place after the workshop based on the interests and challenges of each country.

In these exchanges with the peers the current state of sewage sludge management in Lebanon, Morocco and Palestine was discussed. The exchanges highlighted the need to divert dewatered sewage sludge away from landfills in order to valorize sludge and at the same time to save space in landfills. In all three countries it was clear that there is a need to implement procedures and legislation that will facilitate the final use and disposal of sewage sludge to routes other than landfills, with the priority seen as the land application of sewage sludge.

2. Main issues addressed

The following pressing issues are targeted within the document, related to sewage sludge management with a strong focus on land application:

- Definition of boundaries
- Establishment of minimum sewage sludge treatment processes
- Different types of sludge
- Quality standards for sewage sludge applied to land
- Quality standards for soil where sewage sludge is applied
- Land uses of sludge
- Permitting procedure for land application of sewage sludge
- Code of practice for the safe application of sewage sludge to land
- Social dimension and dissemination actions
- Other uses of sludge
- Use of recovered products

2.1 Definition of boundaries

The first issue which sludge management legislation should consider is to accurately define which types of sludge are included and which are not within the legislation. To do this, it is first important to provide some basic definitions (EC, 1991).

- Municipal/urban wastewater: means domestic wastewater and a mixture of domestic and industrial wastewater
- Domestic wastewater: wastewater which is produced from households and originates mainly from human metabolism

- Industrial wastewater: wastewater produced and discharged from the premises of any industry or trade which does not have the characteristics of domestic wastewater
- Sludge: by-product of wastewater treatment plants produced during primary and/or secondary sedimentation
- Sewage sludge: by-product of municipal wastewater treatment plants produced during primary and/or secondary sedimentation
- Hazardous sludge: Sludge which contains one or more of the specified pollutants in larger concentrations that the limits requited for land application of sludge
- Industrial sludge: by-product produced in industrial wastewater treatment plants as a result of sedimentation

As this work considers the application of sludge in agriculture, it is important to specify the type of sludge. The main type of sludge that is included is sewage sludge which is produced within municipal wastewater treatment plants. This is produced during primary sedimentation and/or during final sedimentation. Sewage sludge needs to meet specific limits to allow its application in land. This is accomplished after suitable treatment resulting in its stabilization, hygienization and water removal.

As municipal wastewater treatment plants often receive industrial discharges, these discharges need to be regulated, so that the physicochemical characteristics of the raw municipal sewage entering the plant are not disturbed. Disposal of improperly treated industrial wastewater into the municipal sewers may have a negative impact on the produced sewage sludge; higher concentrations of heavy metals and organic micropollutants can accumulate in sludge.

The physicochemical characteristics of industrial discharges need to conform to specific characteristics. Typical limit values for industrial discharges into the sewerage network are given in Table 1. In the cases where this is not possible to regulate (e.g. illegal industrial discharges into the sewerage network occur, there are no limits for industrial discharges into municipal sewers), then there is the risk that sludge will not meet the quality standards required for it in order to be applied to land. In all cases, the suitability of the produced sewage sludge has to be checked by comparing it with the required limit values to which the sludge applied to land should conform.

Hazardous sludge should not be applied to agriculture and therefore is excluded from the analysis of this work. In terms of industrial sludge, a distinction has to be done between industrial activities which produce sludge which does not contain potentially hazardous substances and industrial activities which produce potentially hazardous sludge. Table 2 shows a tentative list of industrial activities which can be included for the agricultural use of the produced industrial sludge. As mentioned, this list is tentative and other industries can be included provided they produce sludge that can be suitable for agricultural use. Industrial sludge produced from chemical industries, tanneries, metal plating industries should not be included in the list.

Table 1: Proposed limit values for industrial discharges into the municipal sewerage network (adapted from limits given by the Athens Water Supply and Sewerage Company EYDAP S.A.).

Parameter	Symbol	Units	Limit Value or range for discharge into the municipal sewerage network
pH	pH		6-9
Temperature	T	^oC	35
Biochemical Oxygen Demand	BOD_5	mg/L	500
Chemical Oxygen Demand	COD	mg/L	1000
Total Suspended Solids	TSS	mg/L	500
Total Dissolved Solids	TDS	mg/L	3000
Oil and grease	-	mg/L	50
Ammonia nitrogen	NH_4-N	mg/L	40
Nitrite nitrogen	NO_2-N	mg/L	5
Nitrate nitrogen	NO_3-N	mg/L	60
Phosphate	PO_4-P	mg/L	10
Sulphate	SO_4^{2-}	mg/L	1500
Sulphite	SO_3^{2-}	mg/L	1
Hydrogen Sulphide	H_2S	mg/L	1
Aluminium	Al	mg/L	10
Antimony	Sb	mg/L	5
Arsenic	As	mg/L	0.5
Barium	Ba	mg/L	15
Beryllium	Be	mg/L	20
Boron	B	mg/L	10
Cadmium	Cd	mg/L	0.5
Chromium(III)	Cr(III)	mg/L	5
Chromium(VI)	Cr(VI)	mg/L	0.5
Cobalt	Co	mg/L	10
Copper	Cu	mg/L	5
Cyanide	CN-	mg/L	3
Fluorine	F	mg/L	20
Iron	Fe	mg/L	15
Lead	Pb	mg/L	3
Manganese	Mn	mg/L	10
Mercury	Hg	mg/L	0.02
Molybdenum	Mo	mg/L	10
Nickel	Ni	mg/L	10
Phenols		mg/L	10
Selenium	Se	mg/L	0.2
Zinc	Zn	mg/L	20

Silver	Ag	mg/L	5
Thallium	Tl	mg/L	2
Tin	Sn	mg/L	10
Titanium	Ti	mg/L	10
Uranium	U	mg/L	0.2
Free Chlorine	Cl_2	mg/L	5

Table 2: Tentative list of Industrial activities producing sludge that can be applied in agricultural land after suitable treatment

Dairy industries
Breweries
Food and beverage industries
Meat processing industries
Industries producing alcohol and alcoholic drinks
Aquaculture industries
Malt industries
Potato processing industries
Industries producing livestock food
Industries producing plant-based products

2.2 Establishment of minimum sewage sludge treatment processes

Sewage sludge that is applied to land should undergo appropriate treatment in order to make the sludge suitable for agricultural application. It is therefore important to establish **minimum sewage sludge treatment processes.** Water utilities and/or other sludge management companies should have the flexibility to use other treatment processes than the minimum specified, provided they are able to prove that the selected treatment process results in at least the same level of treatment as the minimum specified treatment methods. The minimum sludge treatment processes specified in this document follow the treatment processes specified within the third working document of sludge with the addition of the composting process (EC, 2000). **Specifically two types of treatment processes are defined: (i) advanced treatment and (ii) conventional treatment of sewage sludge.**

Advanced treatment of sewage sludge consists of the processes of anaerobic and aerobic digestion, thermal treatment, composting and lime conditioning under the following conditions (EC, 2000):

- Thermal drying ensuring that the temperature of the sludge particles is higher than 80°C with a reduction of water content to less than 10% and maintaining a water activity above 0.90 in the first hour of treatment;
- Thermophilic aerobic stabilization at a temperature of at least 55°C for 20 hours as a batch, without admixture or withdrawal during the treatment;

- Thermophilic anaerobic digestion at a temperature of at least 53°C for 20 hours as a batch, without admixture or withdrawal during the treatment;
- Thermal treatment of liquid sludge for a minimum of 30 minutes at 70°C followed by mesophilic anaerobic digestion at a temperature of 35°C with a mean retention period of 12 days;
- Conditioning with lime reaching a pH of 12 or more and maintaining a temperature of at least 55°C for 2 hours;
- Conditioning with lime reaching and maintaining a pH of 12 or more for three months.
- Composting using additives (green material, woodchips, sawdust and similar material) to achieve a temperature above 50°C for at least 5 days and a temperature above 35°C for at least 12 days.

The treated sludge should be free of *Salmonella spp.* in 50 g of sample (wet weight) and the treatment should decrease at least by 6 $\log_{10}$Escherichia Coli to less than 500CFU/g sludge sample. Furthermore, liquid slurry needs to be dewatered and dried to a solids concentration of at least 30%.

The conventional treatment processes of sewage sludge are less effective than the advanced ones and as a result produce lower quality compost, limiting their applications. The conventional methods adopted consist of aerobic and anaerobic digestion and lime conditioning:

- Thermophilic aerobic stabilization at a temperature of at least 55°C with a mean retention period of 20 days;
- Thermophilic anaerobic digestion at a temperature of at least 53°C with a mean retention period of 20 days;
- Conditioning with lime ensuring a homogenous mixture of lime and sludge. The mixture shall reach a pH of more than 12 directly after liming and keep a pH of at least 12 for 24 hours;
- Mesophilic anaerobic digestion at a temperature of 35°C with a mean retention period of 15 days;
- Extended aeration at ambient temperature as a batch, without admixture or withdrawal during the treatment period. The minimum time length of the treatment shall be laid down by the competent authority taking into consideration the prevailing climatic conditions in the area where the treatment plant is located.
- Simultaneous aerobic stabilization at ambient temperature. The minimum time length of the treatment shall be laid down by the competent authority taking into consideration the prevailing climatic conditions in the area where the treatment plant is located.

The sludge treatment shall at least achieve a 3 $\log_{10}$ reduction in *Escherichia Coli.* Furthermore, liquid slurry needs to be dewatered/dried to a solids concentration of at least 30%.

The above minimum treatment standards (both advanced and conventional) should form the framework rather than a rigid treatment regime. If the competent authority is able to provide solid evidence that an alternative treatment scheme can accomplish at least the same level of treatment, then it should be possible to use this process.

2.3 Different types of sludge

Based on the type of treatment applied, two different types of sludge are distinguished: High Quality Sludge (HQS) and Medium Quality Sludge (MQS). HQS has undergone the advanced treatment processes specified in Section 2.2, while MQS has undergone the conventional treatment processes also specified in Section 2.2. The different type of sludge quality only refers to the type of treatment undergone and is not related to the type of feedstock, which is in all cases sludge (sewage sludge, and specific types of industrial sludge as documented in Table 2). The Lebanese compost ordinance defines 4 different types of compost (Compost Grade A, B, C and D). The main distinction is the type of source material and the level of maturation resulting from treatment. For example, Grade A compost is produced from source-separated biowaste which produces high quality feedstock, while Grade D compost is derived from organic raw material generated by mechanical treatment, which has much more impurities. Furthermore, Grade A compost is considered mature, while Grade D is considered immature. However, this Ordinance regulates compost produced from biowaste and does not include sewage sludge.

In terms of final quality HQS should not have any *Salmonella spp.* in 50 g of sample (wet weight) and *Escherichia Coli* should be less than 500 CFU/g sludge sample. The MQS should have *Escherichia Coli* less than 3000 CFU/g sludge sample.

2.4 Quality standards for sludge applied to land

It is important to specify the quality standards of the sludge which is to be applied to land. The main criticism against the EU Directive 86/278/EEC "*on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture*" (EC, 1986) is that it only includes limit values for heavy metals in sewage sludge; it does not include limit values for pathogens and for organic micropollutants. Furthermore, the heavy metal limits are specified as a range which is very wide. In this Section we propose limits which sewage sludge should abide in order to allow its use in agriculture. In Table 3 the proposed limit values for heavy metals in sewage sludge are given in comparison to the ones specified in the Directive 86/278/EEC. The limit values are the ones adopted for 2025 by the third working document on sludge (EC, 2000).

Table 3: Heavy metal limit values proposed in this work (based on the third draft working document on sludge) and as specified in Directive 86/278/EEC

Element	Symbol	Limit values of Directive 86/278/EEC (mg/kg dry matter)	Proposed limit values (mg/kg dry matter)
Cadmium	Cd	20-40	2
Copper	Cu	1000-1750	600

Nickel	Ni	300-400	100
Lead	Pb	750-1200	200
Zinc	Zn	2500-4000	1500
Mercury	Hg	16-25	2
Chromium	Cr	-	600

As mentioned earlier, it is important to specify limit values for selected organic micropollutants which are present in sewage sludge. Table 4 shows the proposed limit values for organic micropollutants based also on the third working document on sludge. This list needs to be periodically reviewed and revised based on the organic micropollutants which are regulated.

Table 4: Limit values for organic micropollutants for sludge applied to land (based on the third draft working document on sludge)

Compound	Symbol	Proposed limit value (mg/kg dm)
Sum of halogenated organic compounds	AOX	500
Linear alkylbenzene sulphonates.	LAS	2600
Di(2-ethylhexyl)phthalate.	DEHP	100
Nonylphenol & nonylphenolethoxylates with 1 or 2 ethoxy groups	NPE	50
Sum of polycyclic aromatic hydrocarbons	PAH	6
Sum of the polychlorinated byphenils	PCB	0.8
Polychlorinated dibenzodioxins/ dibenzofuranes	PCDD/F	0.1

2.5 Quality standards for soil where sewage sludge is applied

The soil where sewage sludge is applied should be monitored to ensure that the values of heavy metals in soil are below specific threshold values and that there is no accumulation of heavy metals above the limits due to the periodic application of sewage sludge to land. For this reason, it is important to specify limits regarding the annual heavy metals loads which are applied to land as well as limits for heavy metal concentrations in soil.

Table 5 shows the maximum allowable loadings for heavy metals per hectare of land per year, as these are specified in Directive 86/278/EEC as well as the proposed limits based on the third working document of sludge for the year 2025. The latter values (which we adopted for our work here) are much lower than the ones specified in the Directive because the target is to avoid any accumulation of heavy metals in the soil. This means that the amount of heavy metals applied to land through sewage sludge application should not exceed the capacity of plants to uptake this plus any losses.

The competent authority can allow an increase in the loading rate for copper and zinc in the cases where sludge application is implemented at copper or zinc-deficient land. However, for this to happen an agronomic study is required demonstrating the benefits of this to crops.

Limit values are also set for heavy metals in soil where sewage sludge is applied. In the Directive 86/278/EEC the limit values are given only for soil with pH value in the rage of 6-7. However, it is important to consider also soil which has a pH lower than 6 and higher than 7. This is reflected in the limit values set by the third working document on sludge. These limits are the ones proposed within this work and are given in Table 6. When the soil has a pH value 5 ≤ pH ≤ 6 the maximum allowable limits are lower due to the potentially higher mobility of the metals.

Table 5: Maximum allowable loading of heavy metals to the soil

Element	Symbol	Limit values of Directive 86/278/EEC (g/ha/year)	Proposed limit values (g/ha/year)
Cadmium	Cd	150	30
Copper	Cu	12,000	3,000
Nickel	Ni	3,000	900
Lead	Pb	15,000	2,250
Zinc	Zn	30,000	7,500
Mercury	Hg	100	30
Chromium	Cr	-	3,000

Table 6: Heavy metals limit values for the soil where sludge is applied

Element	5 ≤ pH ≤ 6 (mg/kg dm)	6 ≤ pH ≤ 7 (mg/kg dm)	pH ≥ 7 (mg/kg dm)
Cadmium	0.5	1	1.5
Copper	20	50	100
Nickel	15	50	70
Lead	70	70	100
Zinc	60	150	200
Mercury	0.1	0.5	1
Chromium	30	60	100

Even when the concentration of an element in a land area is found to be higher than a limit value specified in Table 6, the competent authority can still allow the application of sludge on land by considering:

- The uptake of heavy metals by plants
- The intake of heavy metals by animals
- The groundwater contamination
- The long-term effects on bio-diversity and in particular on soil biota.

The evaluation should be done on a case by case basis. Continuous monitoring of these areas is required to ensure that there is no excessive accumulation of heavy metals in soil.

It is also important to specify the permissible uses of sewage sludge. This should be based on the quality of the produced sludge. Consequently, different uses should be assigned to High Quality Sludge and to Medium Quality Sludge which undergo advanced and conventional treatment respectively. Table 7 proposes uses for the land application of sewage sludge based on the treatment level it has received. This Table has been modified from the one given in the third working document on sewage sludge (EC, 2000). The land application of sewage sludge to cultivations of fruits and vegetables and to urban areas is only allowed for sludge which has undergone advanced treatment.

Table 7: Proposed allowable uses of treated sewage sludge (modified EC, 2000)

Application	High Quality Sludge	Medium Quality Sludge
Fruit and vegetable crops in contact with the ground	Yes	No
Parks, green areas, city gardens, urban areas where the public has access	Yes	No
Pasture land	Yes	Yes
Forage crops	Yes	Yes
Arable land	Yes	Yes
Forests	No	No
Land reclamation	Yes	Yes
Trees, vineyards	Yes	Yes

2.6 Permitting procedure for land application of treated sludge

One key barrier to the application of sewage sludge in agriculture is the fact that the permitting procedure can involve bureaucracy and can be time consuming. This can be a very deterring factor for the end users which are usually the farmers. Within the workshop which took place in Athens on sewage sludge management one of the problems which was identified was the involvement of too many public organizations (Ministries, Departments etc.) within the licensing process for sewage sludge utilization in agriculture. On one hand the permitting procedure should be straightforward and rather quick to acquire on the other it should ensure the safety of the users, the consumers and those involved in activities in the proximity of the areas where sewage sludge is applied. Furthermore, in several Mediterranean countries (including Lebanon, Morocco and Palestine) land application of sewage sludge is not regulated. The development of simplified procedures for obtaining a permit to apply sewage sludge is therefore a key element. To allow this, sewage sludge management needs to be regulated by a single Ministry or Department. Below is a licensing procedure that could be followed:

- The users (usually farmers) submit to the relevant authority an application for the agricultural use of sludge.
- Soil samples from the site where sludge is to be applied are collected. Physicochemical analysis is carried out in a public or state-recognized laboratory to check the quality.
- Physicochemical analysis of the sewage sludge to be applied to land is implemented to make sure that the sludge fulfils the required limits in terms of pathogens, heavy metals and organic micropollutants.
- Each cultivator makes a statement of responsibility for the state of land ownership; landlord or tenant. Each cultivator submits the Cultivation Statement, showing all the relevant land information.
- According to the data of the Cultivation Statement, the relevant maps of the nearby area are drawn up to show its location and the access road by the relevant authority.
- After reviewing the supporting documents, the decision is taken for each farm of each farmer and determines the maximum amount of sludge that may be allocated to each parcel per hectare.
- The relevant authority calculates the quantities of sludge and prepares the provision service study for this purpose. The provision of the service shall include the costs of loading, transporting, unloading and distributing of the sludge, which may be allocated to each parcel per hectare.

The above procedure which is proposed, considers that there is only one authority which is involved in the permitting procedure for sewage sludge application. In most Mediterranean countries this is not the case and thus sewage sludge application needs to be evaluated from different Departments and Ministries. For example, in Morocco reclaimed water reuse is intervened (directly or indirectly) by the Superior Council of Water and Climate (CSEC), the Ministry of Interior, Ministry of Equipment, Basins Agencies, Ministry of Agriculture, Ministry of Health, Ministry of Energy and Mines, Environment Department (Choukr-Allah, 2014). Procedures need to become simplified and regulated by 1-2 authorities.

2.7 Code of practice for the safe application of sewage sludge to land

To facilitate the safe and extensive application of sewage sludge in agriculture, it is also recommended to develop a code of practice for the safe application of sewage sludge to land. This code of practice will provide straightforward tips and procedures that farmers can easily follow in order to safely apply treated sewage sludge to land. The Code of practice will not be a legislation document; rather it aims to provide a straightforward guide for farmers. It should be written in a very simple manner to be understood by non-experts. To also facilitate farmers who cannot read and write it is also recommended to develop a short video which can be shown to farmers during dissemination activities to promote sewage sludge reuse. The Code of practice can include issues such as how to apply for a permit, to what type of cultivations to use treated sewage sludge, ways of sludge application to land, how to take samples from soil and sludge for analysis, how to monitor the field, dangerous practices which should be avoided and other issues. Previous experience has shown that the development of a code of practice for farmers together with appropriate legislation can strongly support reuse applications. For example, in Cyprus reclaimed water reuse legislation together with a relevant Code of Practice for agricultural irrigation of reclaimed water have resulted in more than 75% of treated municipal wastewater reuse at a National level.

2.8 Social dimension and dissemination actions

In several cases in the Mediterranean region, a severe barrier to sewage sludge application is the social factor and in particular the fears of the end users (i.e. farmers) regarding the potential negative effects resulting from sludge use in land. This was recognized also through the peer-to-peer exchanges which were implemented. Often, the public is against the development of infrastructure such as wastewater treatment plants, sludge treatment facilities, incineration plants close to their houses (so called NIMBY syndrome).

The implementation of appropriate legislation regarding sewage sludge management needs to be coupled with extensive dissemination activities at a farmer and at a public level. Dissemination activities can take the form of workshops, seminars and open field demonstration activities of sewage sludge application. It is important in these activities to "show how this is done in a real environment" and not to limit the actions to seminars. The relevant authorities need to provide resources for the organization of such events. Furthermore, farmers who use sewage sludge in agriculture can be given incentives for this, at least during the early stages of its implementation. These incentives can be in the form of subsidies or lower cost of water use. Dissemination activities should also span to the consumers of products (i.e. public) to inform them about the safety of these practices and the benefits resulting from treated sewage sludge application to land.

2.9 Other potential uses of sewage sludge

Although the land application of sewage sludge was recognized through the peer-to-peer activities with Lebanon, Morocco and Palestine as the most important sludge management activity it is important to also consider the other viable routes for sewage sludge management. As mentioned earlier, the peer-to-peer activities highlighted the need to divert dewatered sewage sludge away from landfills in order to valorize sludge and at the same time to save space in landfills. Thermal treatment of sewage sludge (i.e. incineration, gasification, pyrolysis) to produce energy was also discussed in the peer-to-peer activities and particularly in the case of Lebanon. Although the emphasis of this report is on land application of sewage sludge a few points regarding thermal treatment of sewage sludge are considered.

- Any thermal treatment option for sewage sludge management has a high capital cost which is usually not affordable for most South Mediterranean areas
- Dewatered sludge has a very high water content which usually ranges from 75-80%. Therefore, a lot of energy needs to be provided to evaporate the water from the dewatered sludge.

- The calorific value of sewage sludge is moderate. Dried sewage sludge has calorific value of only 3300 kcal/kg when biowaste has over 4500 kcal/kg and car tires 8300 kcal/kg.
- Concerns about mercury (which is very volatile) during incineration in many occasions requires co-incineration rather than mono-incineration

Thermal treatment processes have progressed significantly in the last years, particularly in process optimization and in the treatment of the gaseous emissions resulting from the process. The resulting gaseous emissions should be treated to a very high standard; and there is technology available to achieve this. Mediterranean countries which want to move towards thermal treatment of sewage sludge should implement strict limits for the resulting gaseous emissions and make sure that the resulting ash is properly managed.

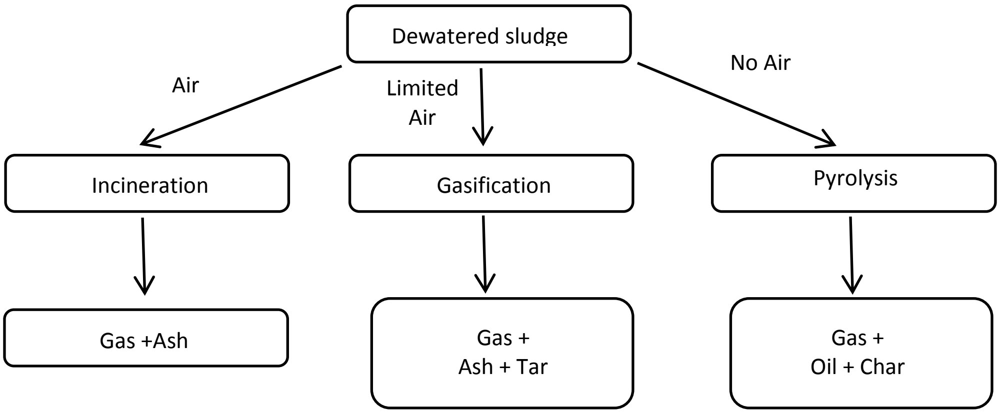

Figure 1: Diagrammatic representation of the different products resulting from the three thermal treatment processes of sewage sludge

2.10 Potential for use of recovered products

In recent years, technologies for the recovery of nutrients from sewage sludge and sludge reject water have emerged and have been successfully applied at industrial level. These technologies produce pure products which are of much higher quality than sewage sludge. The market value of sewage sludge is only 3-5 € per ton, while struvite is sold at a price of over 70 € per ton and in some cases above 150 € per ton. At the moment, investing in such technologies is expensive. However, in the future, the cost of these technologies is expected to decrease, while the cost of phosphorites and other mineral raw materials for production of fertilizers is expected to increase because of their scarcity. Consequently, sewage sludge use will have to compete in the market with these pure chemicals. To allow the use of such materials in agriculture, appropriate legislation should be implemented. It is important to consider that such materials are no longer waste, provided they meet certain quality criteria. Such quality criteria need to be put in place by the relevant authorities to allow the subsequent use of such recovered products.

3. Conclusion

This document is based on the knowledge generated through the peer-to-peer activities which took place with peers from Lebanon, Morocco and Palestine. It was decided early in the exchange process that the most important aspect for them is the proper land application of sewage sludge. In all three countries, but also for all countries of the region, it is important to introduce and effectively implement a solid legislative framework regulating this.

This document serves as a guide for the application/use of sewage sludge in agriculture. Among other things, the document provides specific boundaries to the sludge that should be considered, it specifies basic parameters and limits values that should be considered, the type of treatment sludge should receive, the types of sludge and sludge uses based on the treatment level, as well as the relevant procedures for obtaining a permit. The importance of dissemination activities and the regulation of pure nutrients deriving from sewage sludge is also discussed.

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