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Preparation and revision of the National Waste Planning documents

National Sludge Management Strategy 2024-2034

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APPENDICES

LIST OF ABBREVIATIONS

CFCD	Central Financing and Contracting Department
EBRD	European Bank for Reconstruction and Development
EIA	Environmental Impact Assessment
EUD	European Union Delegation
ELV	End-of-life Vehicle
EPR	Extended Producer Responsibility
EU	European Union
EUR	European monetary unit (€)
FS	Feasibility Study
GDP	Gross Domestic product
GVA	Gross Value Added
MoEPP	Ministry of Environment and Physical Planning
MKD	Macedonian Denar
MSW	Municipal Solid Waste
NSMS	National Sludge Management Strategy
NWMS	National Waste Management Strategy
OPEX	Operating Expenditure
p.e.	Population equivalent
PSC	Project Steering Committee
PUC	Public Utility Company
RNM	Republic of North Macedonia
RWMP	Regional Waste Management Plan
SEA	Strategic Environmental Assessment
SME	Small-to-Medium Enterprise
SWM	Solid Waste Management
t.ds	Ton dry solids
ToR	Terms of Reference
WM	Waste Management
WG	Working Group

Executive Summary

The executive summary will be included in the final version of this document.

1 Introduction

1.1 General Role of the National Sludge Management Strategy

The National Sludge Management Strategy 2024-2034 (the NSMS) represents the national policy for the management of sludge generated as result of the treatment of urban wastewater. It forms the basis of the realisation of a sustainable and cost-effective system for the treatment, use and disposal of sludge. The Strategy provides direction for sludge management for the coming ten-year period (2024-2034) and aims at preventing negative environmental and public health impacts caused by improper sludge management.

The NSMS is an instrument to establish the Government's ambitions for a sustainable sludge management system and it thereby forms the policy basis for the realisation of infrastructure for the treatment of sludge and it defines the framework for utilisation of sludge in, for instance, agriculture.

The NSMS is one of several environmental policy documents of the Republic of North Macedonia (RNM) and, since sludge is a waste stream, it is highly linked with the National Waste Management Strategy 2024-2036 (NWMS) of the RNM. Provisions of the NWMS and other environmental policy documents have been taken in to account while developing the current document.

1.2 Basis for preparing the NSMS

The NSMS 2024-2034 has been prepared on the basis of the legal requirements included in the Law on Waste Management. Moreover, the planned increase in the number of waste water treatment plants will see an increase in sludge production in the coming years. Managing the increasing volume of sludge being generated demands a planned approach for which the NSMS provides the policy basis.

1.3 Scope of the NSMS

The NSWMS 2024-2034 presents the Government's policy for the management of sludge generated as result of the treatment of urban waste water which has code 19-08.05 in the list of wastes.

2 Existing Sludge Management

2.1 Legal and Institutional Framework

Legal Framework

Sludge management is largely regulated by the Law on Waters and the rulebooks elaborated based on the Law on Waters, including:

- Rulebook on the methodology and procedures for sludge use, maximum concentration of heavy metals in soil in which the sludge was used, concentration of heavy metals in sludge, in accordance with its use and maximum annual quantity of heavy metals that can be deposited in soil (OGRM no. 73/11).
- Rulebook on the form, content and manner of submitting data including type of information on use of sludge resulting from urban waste water treatment according to sludge use, treatment, composition and place of use (OGRM no. 60/11) (abbreviated to RDISU).
- Rulebook on the form and content of the application and the permit for sludge use, as well as the manner of issuance of the permit for sludge use (OGRM no. 60/11).
- Rulebook on the methodology, referent measuring methods, manner and parameters for waste water monitoring, including the monitoring of sludge resulting from the urban waste water treatment (OGRM no. 108/11).
- Rulebook on the manner of transfer of information from monitoring of discharged wastewater and the form and content of the form on which such data are delivered (OGRM no. 108/11).

The legal framework regulates the use of sludge and sets limits for concentrations of heavy metals in sludge and soils within which use of sludge in

agriculture is allowed. In addition to limits for heavy metals, limits for bacterial contamination. The limits are presented in the table below.

Table 1. Limits for concentrations of heavy metals in sludge and soils

Parameter	Max. concentration in soil (at pH 6-7) in mg/kg d.s.	Max. concentration in sludge in mg/kg d.s.
Heavy metals		
Cadmium	1-3	20-40
Copper	50-140	1,000-1,750
Nickel	30-75	300-400
Lead	50-300	750-1,200
Zinc	150-300	2,500-4,000
Mercury	1-1.5	16-25
Bacteria		
Salmonella spp.		20 cfu/g.ds
Escherichia coli		1 cfu/g.ds
Clostridium perfrigens		1 cfu/g.ds

In addition to the above, the legal framework sets limits for the annual application (10-year average) of heavy metals in sludge in kg per hectare and year. International limits are however substantially more stringent than the limits in the Macedonian legislation.

The limits as included in the above table, especially the limits for bacterial contamination, severely reduce the possibility of use of sludge in agriculture. Internationally, both within and outside the EU, limits for bacterial contamination for the use of sludge in agriculture are unusual and not regarded necessary as long as sludge is treated prior to the application or in case untreated sludge is applied by injection into or mixing with the soil.

In addition to the Law on Waters and associated rulebooks, the Law on Environment and the Law on Waste Management with its associated rulebooks have relevance for sludge management in case of disposal or incineration of sludge, most notably the permitting requirements and limit values for incineration and co-combustion.

Institutional framework

At the national level, the MoEPP is the main responsible authority for sludge management. MoEPP, inter alia, issues permits for the transportation, treatment and use of sludge and IPPC permits for incineration or co-combustion of sludge.

MoEPP is further responsible for keeping records of the production, treatment, composition and use of sludge. Monitoring of the use of sludge is the responsibility of the State Environmental Inspectorate.

Municipalities are responsible for providing communal services in their territory including the collection and disposal of municipal waste and including the drainage and treatment of waste water. The responsibilities include the establishment of landfills for waste disposal and (organising) the transport of waste to the landfills. In case of disposal of sludge at landfills, the municipalities are the responsible institution while the operational responsibility may be transferred to a licensed waste transporter and/or landfill operator which can either be a PUC or a private company. Inspection of the operations of waste transport and waste disposal is the responsibility of the State Environmental Inspectorate and authorised local inspectors.

Sludge producers are responsible for reporting on sludge generation, composition, treatment, use and disposal. Sludge users are responsible for obtaining a permit for sludge use, reporting on sludge use to MoEPP and for monitoring sludge and soil in accordance with their permit and the legal requirements.

2.2 Current and Future Sludge Generation

In this section, sludge amounts generated, and to be generated, are expressed as tonnes dry solids per year (t.ds/y) since this is the only objective measure to express sludge quantities. However, it should be noted that in addition to dry solids, sludge is composed of water. In primary sludge, as removed from the wastewater treatment process, sludge contains only 1% or 2% dry solids. As result of stabilisation, thickening, conditioning and dewatering processes, the dry solid content of sludge increases. However, sludge to be removed from the WWTP still contains water and, depending on the sludge treatment processes applied, the dry solid content may be in the range of 10% to 60%. Sludge amounts including the water content and expressed in tonnes may thus be double or even triple or quadruple the sludge amount expressed in t.ds.

Current sludge generation

Currently there are 16 operational wastewater treatment plants (WWTPs) in North Macedonia. In addition, there are various WWTPs that are not operating due to lack of maintenance and repair. Total installed capacities of operational respectively non-operational WWTPs are 594,000 p.e. and 71,000 p.e. while the associated sludge production and potential sludge production are approximately 15,000 t.ds/y and 2,000 t.ds/y (rounded figures).

Current sludge generation for the operational WWTPs is presented in the following table.

Table 2. Current sludge generation from operational WWTPs in the RNM

Location of WWTP	Capacity in p.e.	Sludge generation in t.ds/y
Eastern Region		
Kochani	65,000	1,680
Berovo	14,000	46
Cesinovo-Oblesevo settlement Kucicino	700	18
Southwestern Region		
Ohrid and Struga settlement Vranishte	120,000	2,131
Makedonski Brod	5,000	125
Kichevo	48,000	1,543
Southeastern Region		
Strumica	60,207	1,241
Radovish	25,000	636
Gevgelija	30,000	1,314
Dojran (settlement Nov Dojran)	12,000	300
Pelagonija Region		
Prilep	95,000	2,957
Northeastern Region		
Kumanovo	91,000	2,520
Skopje Region		
Ilinden (for the settlement Ilinden)	5,554	139
Ilinden (for the settlement Kadino)	2,614	65
Volkovo	19,500	44
Gazi Baba – settlement Smilkovci	371	9

The capacities of WWT and sludge production for those plants that are currently non operational or planned to be restarted (12), are presented in the next table.

Table 3. Current non operational WWTPs in the RNM

Location of WWTP	Capacity in p.e.	Sludge generation in t.ds/y
Vardar Region		
Sveti Nikole	15,000	375
Lozovo	2,395	60
Jasenovo	/	/
Eastern Region		
Karbinci	600	15
Southwestern Region		
Debarca	2,000	50
Pelagonijan Region		
Resen (settlement Ezerani)	13,791	345
Dolneni	3,200	80
Krivogastani	3,200	80
Northeastern Region		
Rankovce	1,500	38
Skopje Region		
Cucer Sandevo	9,000	225
Saraj	17,000	425
Gazi Baba – settlement Jurumleri	3,256	81

Additionally, there exists 22 small WWTPs that were identified in 2017 and which are not operational. The data about these facilities is limited thus it is estimated an additional capacity of approx. 25,000 p.e., that represents approximately 625 t d.s./year that will be generated by these 22 small WWTPs when they are in operation.

Future sludge generation

Based on planned expansion of waste water treatment it is expected that in the coming 3 to 5 years 10 new WWTPs will be constructed and that thus the sludge generation will increase. A forecast for the amounts of sludge to be generated is, together with the planned capacities of the new WWTPs, presented in the table below.

Table 4. New WWTPs to be constructed in the RNM

Location of WWTP	Capacity in p.e.	Sludge generation in t.ds/y
Vardar Region		
Veles	50,000	953
Kavadarci	44,032	1,101
Eastern Region		
Shtip	53,000	941
Delchevo	14,985	375
Southwestern Region		
Debar	17,998	450
Vevchani	1,500	38
Pelagonija Region		
Bitola	112,474	2,809
Polog Region		
Tetovo	100,000	2,500
Gostivar	102,685	2,567
Skopje Region		
Skopje	625,000	10,633

The new WWTP to be constructed in the coming years will together produce an estimated amount of approximately 22,500 t.ds/y (rounded up to the nearest 500 t.ds). Together with the sludge produced by currently operational WWTPs and non-operational plants (including the 22 small WWTPs), assuming these will be repaired and put back into operation, the total future sludge generation can be estimated at approximately 39,500 t.ds/y.

With the construction of the 10 planned WWTPs and the assumed repair of the currently non-functional plants (12 plus 22 small WWTPs), the total number of WWTPs in Macedonia will be 60 plants (38 plus 22 small WWTPs). This number is not sufficient to treat all wastewater generated in urban areas in Macedonia. A further increase in the number of WWTPs will be required and a further increase in sludge generation has to be expected. In addition to current and new WWTPs an additional capacity of some 400,000 p.e. is expected to be required and to be realised between 2030 and 2040. Sludge generation in 2040 could then reach an amount of roughly 50,000 t.ds/y.

2.3 Current sludge management practices

For sludge management, two phases can be distinguished. The first phase concerns sludge treatment within the WWTP which may include some or all of the following: sludge stabilisation, sludge thickening, sludge conditioning, sludge dewatering, sludge drying and on-site sludge incineration. The second phase concerns management of (treated) sludge or sludge residue outside the WWTP and this may include useful application, off-site incineration and (landfill) disposal.

In operational WWTPs in Macedonia a variety of sludge treatment methods is currently used. In most, if not all, WWTPs aerobic or anaerobic stabilisation is applied with prior or subsequent sludge thickening. To improved dewaterability, chemical conditioning is used and both mechanical and natural dewatering is applied. In a few cases sludge composting is used as sludge treatment.

Following sludge treatment in the WWTPs, the largest part of the generated sludge is disposed of at municipal landfills while a smaller portion is disposed of on land near or within the premises of the WWTP. A small portion is, after composting, used for soil improvement.

Although the sludge treatment technologies applied within WWTPs in Macedonia are adequate, the sludge treatment equipment used within the operational WWTPs is in general old, not well maintained and prone to breakdowns. Continuity in sludge treatment is therefore not assured.

The management of sludge outside the WWTP is only appropriate in part. Disposal at municipal landfills is a correct disposal method but, the municipal landfills in Macedonia do not meet the national and international requirements and standards. Disposal on land near or within WWTP is not a sustainable solution and alternatives will have to be found. Use of compost, provided it meets the quality standards, is the best current sludge management method however, sludge composting is associated with unpleasant odour emissions.

3 Evaluation of Options for Sludge Management

3.1 Treatment Options

Options for sludge stabilisation

Sludge stabilisation aims at obtaining a material (sludge) better suited for further processing, at reducing the amount of organic matter in the sludge and thus at reducing the amount of dry solids, at eliminating odour producing substances and at the improvement of the hygienic properties of sludge.

The most appropriate sludge stabilization methods include: sludge reed beds for small WWTPs, aerobic stabilization (extended aeration) for medium sized WWTPs, and anaerobic digestion for large WWTPs. Large WWTPs may also provide centralized sludge treatment for surrounding small WWTPs where economically justified (costs of sludge transport balanced by the economic scale of large sludge treatment facilities).

Sludge Conditioning

Sludge conditioning aims at improving the dewaterability. The most common and most appropriate method is chemical conditioning in the form of adding flocculant to the sludge. Alternative methods, thermal and physical conditioning, are less suitable because of, respectively, the high energy demand and the increase of sludge amounts.

Dewatering options

Drying beds etc.

In order to reduce moisture content additional treatment of sludge is needed. This can be done in a low-tech/low-cost manner such as drying beds, sludge reed beds and composting. All these dewatering methods require substantial areas of land to be implemented and the dewatering process will take a relative long period of time. Moreover, weather conditions may disturb the drying process, adding to the time required to produce the desired sludge consistency. The mentioned sludge dewatering techniques are therefore suitable for small and medium size WWTPs only.

Mechanical dewatering

Mechanical dewatering is preferred for medium size and larger WWTPs. Various types of equipment are available on the market and several WWTPs in Macedonia have installed such equipment. Available equipment includes centrifuges (e.g. decanters), press filters and sieve belt presses. The available technologies all perform adequately and preference for one or another technology depends on how it fits in the overall design of a WWTP.

Composting of sludge

Composting of sludge is a form of aerobic treatment/stabilisation. Sewage sludge can be combined with other waste materials such as wood chip, straw, rice straw or green wastes prior to composting to provide for a structure proper aeration. Around 20−30% of the volatile solids can be converted to carbon dioxide through composting.

Composting employs natural mesophilic and thermophilic aerobic degradation within a largely static system which is aerated by natural diffusion and is therefore low in energy demand. However, composting is a lengthy process and employs large land areas. Moreover, the composting of sludge is often associated with odour nuisance. Composting is therefore only suitable for small WWTPs away from residential areas/buildings.

3.2 Options for Use

Use of liquid sludge

Raw not stabilised sludge or aerobic stabilised but not dewatered sludge can be used in agriculture by injection of sludge into the soil or by mixing sludge with sandy soil for the production of black soil for gardens and parks. This type of utilisation is not uncommon in Europe but often limited to sludge from small WWTPs. The advantage of using liquid sludge is that the treatment costs for sludge conditioning and dewatering can be avoided. However, negative aspects, especially if the sludge is not stabilised, include the emission of unpleasant odours. Furthermore, the application of raw sludge may give rise to concerns of bacteriological contamination when applied to soils used for food or fodder production.

Utilisation of treated sludge

The use of sludge for agricultural purposes in Macedonia is limited by several factors: dominant presence of small farms in the country where it is impractical to apply the sludge, soil quality of agricultural land is not compliant with quality standards prescribed in the Rulebook for sludge and/or sludge quality does not meet the requirements prescribed in the Rulebook for sludge. The sludge can only be used on large farm enterprises (Vardar, Pelagonia, Northeast and East Regions) where the mechanical sludge spreading should be practicable and the costs and administration of soil monitoring and permitting sludge use in compliance with the sludge Rulebooks are minimized. To achieve wider use of

sludge in agriculture would involve developing the potential of small private farms.

Potential for use of the sludge for land rehabilitation are: mining areas- opencast lignite mines and ash disposal from the thermal power plants, other mining and industrial dump sites, environmental hot spots, quarries and municipal landfills. Some land rehabilitation programmes could utilize potentially large quantities of sludge, but the operational challenge is that such opportunities will occur only periodically and so it is impossible to develop a schedule that could provide reliable and continuous outlets for sludge. Using the sludge in afforestation purposes has no potential in the country.

3.3 Disposal Options

Incineration

Capacity for burning sludge as a supplementary alternative fuel has a potential in few energy intensive industries: ELEM's lignite-fired TPPs, Usje cement factory and FENI Industries; these facilities are geographically well-distributed across the country. These facilities could burn most of the future sludge production but the acceptance of sludge is uncertain and requires technical and financial appraisal by the industries involved to determine whether the co-firing of sludge is a viable option.

The sludge incinerator planned for the future Skopje WWTP is very important as this WWTP will produce about 20% of the future sludge production in Macedonia. Whether additional sludge incinerators, to be realised and new WWTPs to be built, could be an option will have to be investigated through feasibility studies.

Landfilling

Even though the existing landfills are not suitable for sludge disposal, they are the only practicable option for sludge producers. Disposal of sludge in landfills is however contradictory to the policy of diverting (organic) waste from landfills. However, solutions are required to provide sufficient disposal capacities for sludge in the short and medium-term. With the realisation of regional landfills as anticipated in national and regional waste management plans, the disposal of sludge in the sanitary landfills will be possible. In addition, the planning, design, construction and operation of mono-landfill sludge disposal facilities, where it is not feasible to dispose of sludge at municipal landfills or use sludge in agriculture, can contribute to ensuring adequate, environmentally sound sludge management.

4 Goals and Measures in Sludge Management

4.1 Short-term goals and measures

The first step in sludge management is the stabilisation and dewatering of sludge with the WWTPs. In this respect the short-term goal is to ensure the functioning of sludge management within the existing WWTPs and WWTPs planned to be constructed in the short term. In existing WWTPs, the maintenance and repair of sludge stabilisation facilities and dewatering equipment is therefore required.

In WWTPs to be realised in the coming years, facilities for sludge stabilisation shall be standard part of the design and construction. The technologies to be applied shall depend on the capacity of the WWTPs and the location thereof. For small plants in an agricultural setting aerobic stabilisation and thickening of the sludge will in most cases be sufficient, provided that there is the possibility of application of liquid sludge in agriculture. For larger plants, anaerobic treatment of sludge followed by conditioning and dewatering and, in the largest plants, incineration may be more appropriate. Which technology for sludge treatment shall be realised at WWTPs to be constructed in the future shall be determined on a case-by-case basis during the preparation of the feasibility study for each plant taking into account environmental and financial/economic considerations. In all cases, the goal is to ensure appropriate sludge treatment in newly built WWTPs.

Use of sludge in agriculture is considered the most desirable sludge management methods outside the WWTPs, provided the sludge quality meets the set standards and the receiving soils do not exceed the limits for heavy metals as included in the rulebook. The bacteriological limits in the rulebook do however unnecessarily prevent the use of sludge in agriculture. In order to maximise sludge use, the bacteriological limits shall therefore be removed from the legal framework.

Sludge that does not meet the quality requirements for use in agriculture or for which no off-taker can be found shall be properly disposed of. This can either be disposal at a municipal landfill or in a mono-landfill to be constructed near a WWTP. In all cases environmental impacts from sludge disposal shall be prevented or minimised by technological means, i.e. the use of compliant landfills as much as possible. The goal is to ensure capacity for the disposal of sludge that cannot be used in agriculture. To ensure capacity WWTP operators shall conclude a contract with a disposal site manager or organise, in cooperation with the municipality, the construction of a sludge disposal facility at or near their WWTP.

The above short-term goals will not be realised without institutions taking responsibilities for achieving them and not without sufficient financial resources. In order to ensure sufficient financial resources for maintenance and repairs, an inventory of maintenance and repair needs shall be made and a fund for maintenance and repairs shall be established. Fees for water shall be set at a level that includes the costs of wastewater treatment and sludge management, taking into account affordability.

The institutional framework for sludge management will have to be strengthened. It cannot be expected that operators of small WWTPs will be able to independently organise the management of the sludge generated in full compliance with national and international requirements and standards. Regional waste management boards shall therefore be capacitated to take up the responsibility for sludge management. At the national level there is an important role for MoEPP specially in promoting sludge use, e.g. in agriculture, and coordinating the uptake of sludge as a source of energy.

Table 5. List of short-term goals on sludge management

Process or Activity	Goals	Measure	Deadline	Responsible Actor
Sludge Treatment within WWTPs	Ensure sludge stabilisation and dewatering in all existing WWTPs	Improve maintenance and repair faulty sludge treatment equipment	2026	WWTP operators
	Ensure sludge stabilisation and dewatering in all planned WWTPs	Ensure appropriate sludge treatment facilities are included in WWTP designs based on FS	2025	MoEPP
Utilisation of sludge	Maximise the use of sludge in agriculture	Remove bacteriologic limits for sludge from the regulations (rulebook)	2025	MoEPP, GoRNM
Disposal of sludge	Ensure disposal capacity for all sludge that cannot be used in agriculture	Conclude contracts for sludge disposal with landfill operator	2025	WWTP operators
		Construct sludge disposal facilities	2028	WWTP operators; Municipality

Process or Activity	Goals	Measure	Deadline	Responsible Actor
Sludge management	Ensure institutional capacity for sludge management	Capacitate regional waste management boards to organise sludge management at a regional level	2026	MoEPP; international partners
		Capacitate MoEPP to play a coordinating role in sludge management	2025	GoRNM; international partners
Funding of sludge management	Ensure the availability of sufficient financial resources for sludge management	Set-up a fund to financially support WWTP operators to maintain and repair sludge treatment equipment	2026	GoRNM
		Ensure that the water tariffs as set such that the costs of wastewater treatment and sludge management can be covered	2025	WWTP-operators and the Regulatory Commission for energy and water services

4.2 Long-term goals and measures

In the longer term, disposal of sludge at landfills is not compatible with the desire to reduce the disposal of organic waste at landfills. Alternative disposal options shall therefore be introduced. As mentioned, the useful application of sludge is preferred however also in the long term this is not regarded feasible for all sludge generated.

It is not expected that co-combustion of sludge in industrial installations with high energy demand can be realised in the short term. However, once the sludge incinerator in the planned for the Skopje WWTP will be in operation and will prove that sludge can be incinerated without substantial negative impacts on air quality, the acceptance of co-combustion of sludge in for instance power plants and cement plants can increase. The long-term goal therefore is to maximise the incineration and co-incineration of sludge in dedicated incinerators, as the one planned for the WWTP in Skopje, in combination of co-incineration of sludge in industrial furnaces, e.g. in cement kilns.

Table 6. List of long-term goals on sludge management

Process or Activity	Goals	Measure	Deadline	Responsible Actor
Sludge disposal	Maximise sludge incineration and co-incineration	Stimulate industries to accept sludge as source of energy and thus for co-incineration in their furnaces	2032	MoEPP; industry

Process or Activity	Goals	Measure	Deadline	Responsible Actor

5 Action Plan

The action plan for the implementation of the national sludge management strategy 2024 -2034 includes activities to be realised during the validity period of the NSMS. It is anticipated that at the end of the validity period, the sludge management will have been organised in line with the strategy to a large extent. However, follow-up activities will be required since additional WWTPs will be realised also after the validity period of the strategy. Moreover, waste management I general and sludge management in particular is not a project with a start and an end but will requires continuous attention. The need for expansion and renewal of sludge management infrastructure will not stop once a satisfactory sludge management system is in place and, due to wear and tear, sludge management equipment will have to be regularly maintained and replaced on a revolving basis.

With the action plan presented on the following pages, the measures required to be taken for the implementation of the sludge management strategy are concretised. For each measure tasks and activities are presented that, together, will effectively implement the measure. The action plan includes success indicators and the means of verification thus allowing for monitoring of the implementation of the NSMS 2024 – 2034.

Table 7. Improvement measures and success indicators for sludge managemet

Activities	Responsible entities (first listed) and Actors	Deadline for completion	Succes Indicators and means of verification
Measure: Improve maintenance and repair of (faulty) sludge treatment equipment			
Conduct an inventory study on the state of sludge management equipment in WWTPs in Macedonia and the costs for repair and maintenance	ADKOM; MoEPP; WWTP-operators	2025	Study conducted and results published
Prepare maintenance and repair schedules for WWTPs	WWTP operators; ADKOM; MoEPP	2026	Schedules prepared and put on websites of WWTP operators
Implement maintenance and repair schedules	WWTP operators	From 2026 onwards	
Measure: Ensure appropriate sludge treatment facilities are included in WWTP designs based on FS			
Prepare feasibility studies and designs for new WWTPs including sludge treatment equipment	MoEPP; International partners	2028	Designs and feasibility studies conducted as shown by the documents prepared.
Measure: Remove bacteriologic limits for sludge from the regulations (rulebook)			
Revise the Rulebooks on sludge such that the limits for heavy metal content in sludge and soils, the limits for the annual application (10-year average) of heavy metals in sludge in kg per hectare and year and the bacteriological contamination of sludge are fully harmonised with the EU legal framework, i.e. no limits included for bacteriological contamination.	MoEPP; GoRNM	2026	Rulebooks revised as shown by their publication of the Official Gazette.

Activities	Responsible entities (first listed) and Actors	Deadline for completion	Succes Indicators and means of verification
Measure: Conclude contracts for sludge disposal with landfill operator			
Develop model contract for sludge disposal at municipal landfills including requirements for sludge consistencey	ADKOM; landfill operators	2027	Model contract developed and available on ADKOM website
Conclude contracts for sludge disposal at municipal waste landfills	WWTP operators; landfill operators	From 2025 onwards	Contracts concluded as shown by inspections at WWTPs
Measure: Construct sludge disposal facilities			
Complete the preparation of all technical, space managing and investment documents for establishment of the monofil sludge disposal facilities at and/or near WWTPs	MoEPP; Regional waste management boards; WWTP operators, international partners	2028	Preparations for construction of sludge disposal facilities completed as shown by publication of tender documents
Establish contracts for the construction of sludge disposal facilities	MoEPP	2030	Contract concluded as shown by MoEPP website
Construct and supervise construction of sludge disposal facilities	Contractors, MoEPP, WWTP operators	2032	Sludge disposal facilities constructed as shown by site visits
Operate sludge disposal facilities	WWTP operators and/or Regional Waste Management Companies	From 2033 onwards	Sludge disposed of at sludge disposal facilities as shown by site visits
Measure: Capacitate regional waste management boards to organise sludge management at a regional level			
Include staff members for sludge management in the each of the waste management units of the eight Centres for Development of the Pkanning Regions; provide training to said staff members	Regional Waste Management Boards; MoEPP; International Partners	2027	Staff members hired and trained as shown by organisational schemes of the RDCs and training records

Activities	Responsible entities (first listed) and Actors	Deadline for completion	Succes Indicators and means of verification
Measure: Capacitate MoEPP to play a coordinating role in sludge management			
Set-up and staff a unit within the MoEPP Waste Department for the coordination of sludge management in Macedonia	MoEPP; GoRNM	2028	Unit established and staff trained as shown by the organisational scheme of MoEPP and training records
Measure: Set-up a fund to financially support WWTP operators to maintain and repair sludge treatment equipment			
Establish a sludge management fund and develop procedures for application for financial support	GoRNM	2026	Funds established as shown by procedures to apply for funding published on the governments website
Measure: Ensure that the water tariffs as set such that the costs of wastewater treatment and sludge management can be covered			
Prepare detailed accounting to enable the determination of sludge management costs and report operational costs of wastewater treatment and sludge management to the Regulatory Commission on Energy and Water Services	WWTP-operators ADKOM	2026	Accounting system in place and used as shown by reports to the Regulatory Commission
Include the costs of wastewater treatment and sludge management in water tariffs.	Regulatory commission on Energy and Water Services	2026	Water tariffs adjusted to include full costs of wastewater treatment and sludge management as shown by published water tariffs and Regulatory Commission annual reports
Measure: Stimulate industries to accept sludge as source of energy and thus for co-incineration in their furnaces			

Activities	Responsible entities (first listed) and Actors	Deadline for completion	Succes Indicators and means of verification
Conduct a feasibility study into the possibilities of use of sludge as alternative fuel to be used in energy plants, cement industry and other industries with high energy demand (e.g. FENI)	MoEPP; MoE; Industry	2028	Feasibility study conducted and results made public
Conduct pilot test using dried sludge as alternative fuel for co-combustion	Industry	2030	Results of pilot test published
Uptake of sludge as alternative fuel by industry and energy sector	Industry, energy sector	2032	Annual reports by industry and energy sector; permits for sludge use issued by MoEPP

Appendix A Guidelines and code of good practice for use of sludge in agriculture

To be included in final version of the document

A.1 Use in Agriculture

A.2 Use for other purposes.