مسألة ٩ن

v1

Ahmed Gaber-September 13,2021

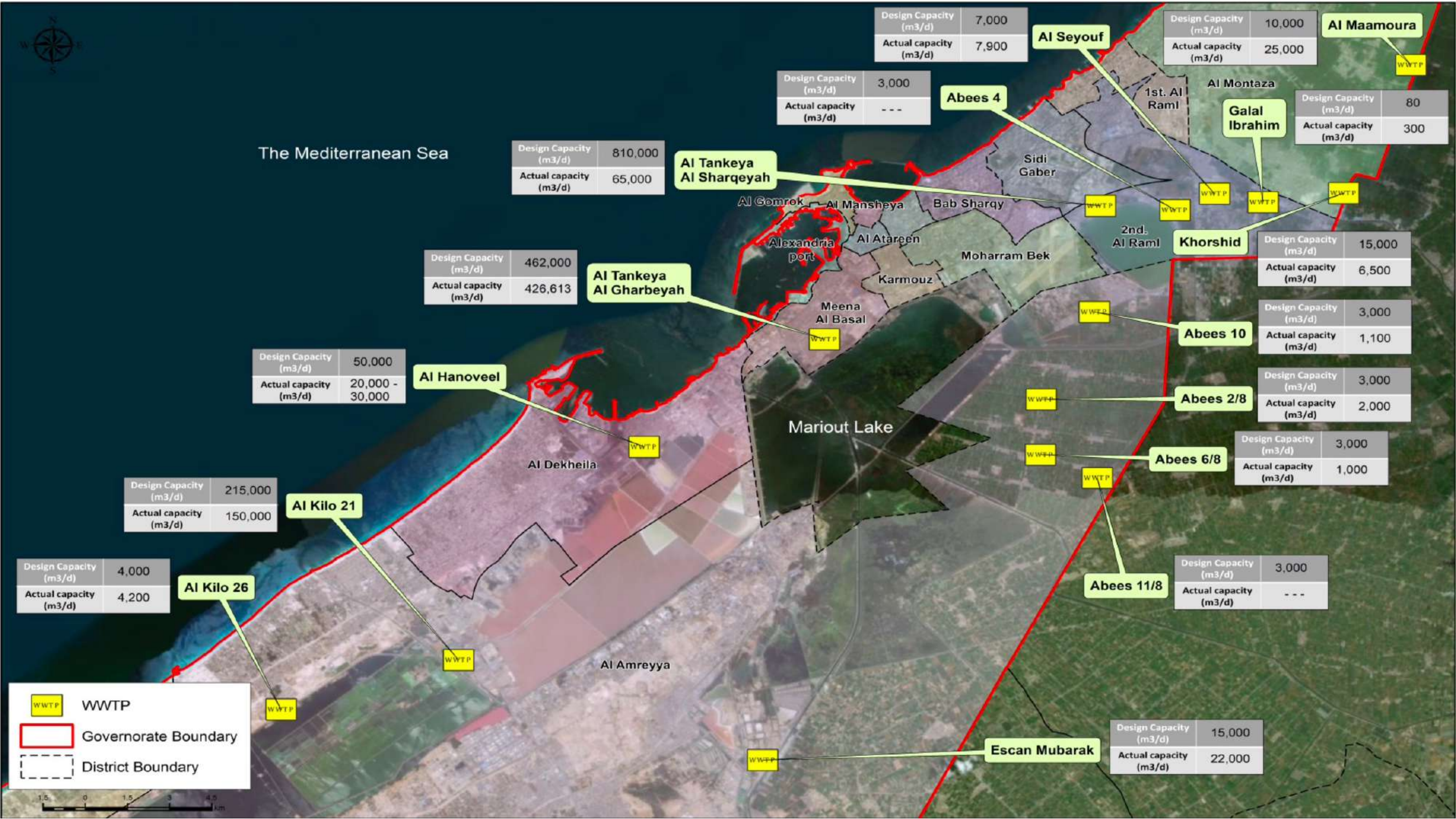
Developed with assistance from Chemonics Egypt’s Review of Current Knowlwdge (ROCK) Team

صياغة المسألة ١

- ٩ ن هي منشأة مركزية تم إنشائها في إطار خطة لتجميع الحمأة بعد خفض نسبة الرطوبة dewatering بها الي حوالي ٢٠٪ في جميع محطات معالجة الصرف الصحي بالإسكندرية (٢٠ محطة).
- ٩ ن هي منشأة صناعية، تجري بها عمليات تحويل الحمأة الي كمبوست compost وفق أصول تكنولوجيا التخمر الهوائي aerobic windrow compostingلانتاج كمبوست الحمأة
- يوجد متغير جوهري في نظم إدارة الحمأة في شركة الصرف الصحي بالإسكندرية يتعلق بتحويل جميع المحطات الي مستوي المعالجة الثنائية، وإضافة مرحلة لتحويل الحمأة الي طاقة في المحطتين الرئيسيتين (الشرقية والغربية) anaerobic digestors

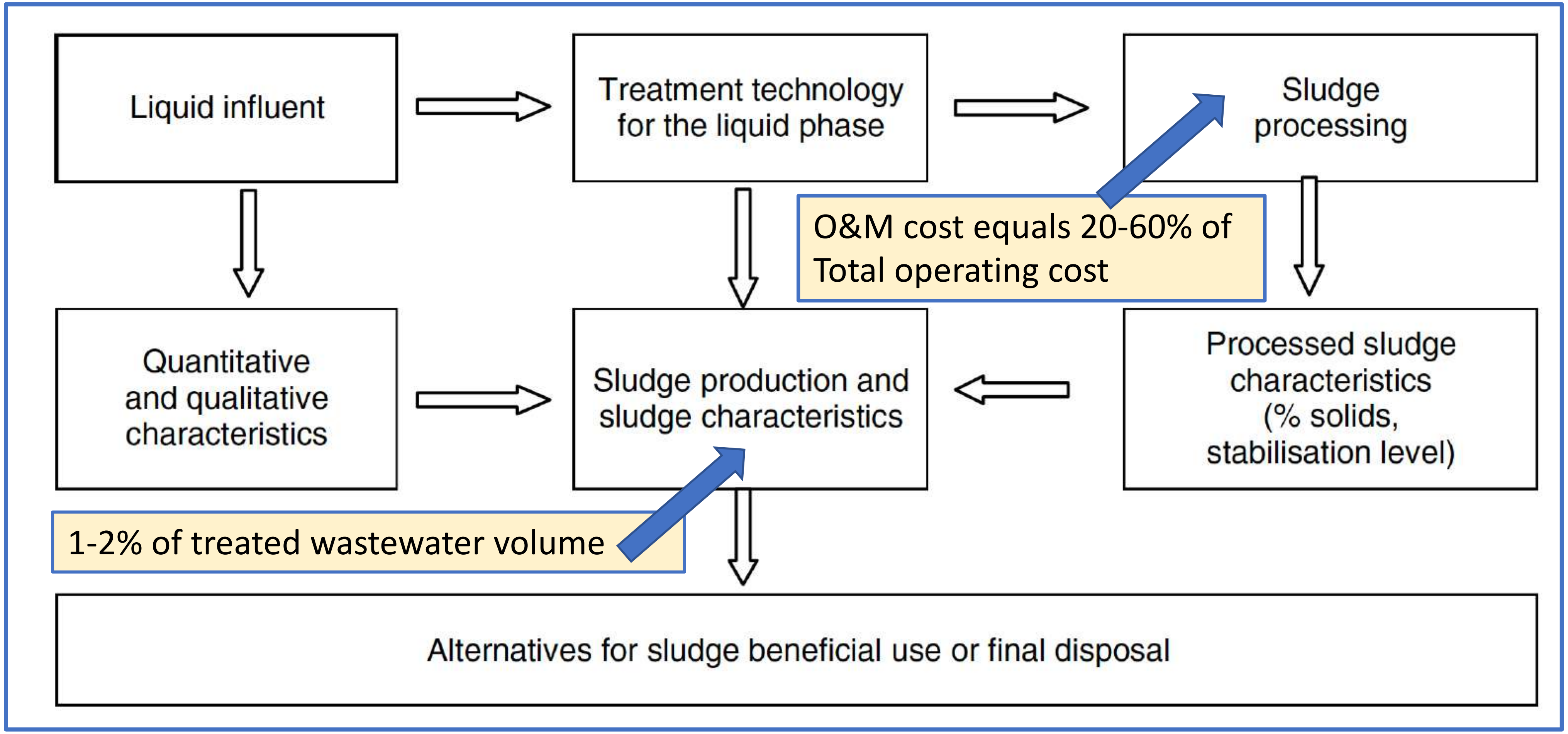
صياغة المسألة ٢

- **السؤال الأول** يتعلق بما يمكن عمله في الوقت الحالي في منشأة ٩ن حيث المدخل هو mechanically-dewatered sludge لتحسين الأداء ورفع الكفاءة أو تحسين اقتصاديات المنشأة؟
- **السؤال الثاني** يتعلق بتأثير إنشاء وحدات تحويل الحمأة الي طاقة في المحطتين الشرقية والغربية، عندما يتم نقل mechanically-dewatered digestate الي منشأة ٩ن، وما هي التكنولوجيا البديلة للكمر الهوائي aerobic composting لتحقيق أعلي استفادة من digestate
- **السؤال الثالث** يتعلق بإيجاد حلول في إطار نظرة أكثر شمولا لإدارة الحمأة علي مستوي جميع محطات الصرف الصحي بالإسكندرية



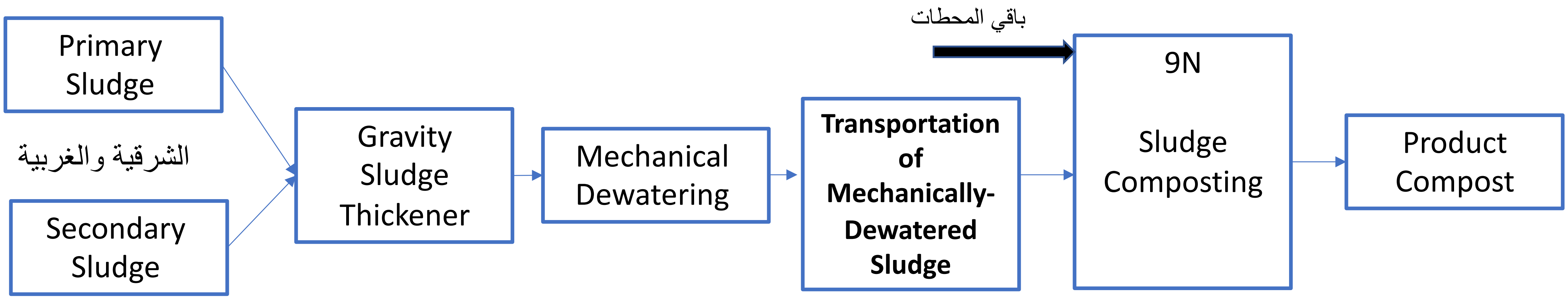
The Mediterranean Sea
Mariout Lake
Al Maamoura
Design Capacity (m3/d) 10,000
Actual capacity (m3/d) 25,000
Al Seyouf
Design Capacity (m3/d) 7,000
Actual capacity (m3/d) 7,900
Abees 4
Design Capacity (m3/d) 3,000
Actual capacity (m3/d) - - -
Galal Ibrahim
Design Capacity (m3/d) 80
Actual capacity (m3/d) 300
Al Tankeya Al Sharqeyah
Design Capacity (m3/d) 810,000
Actual capacity (m3/d) 65,000
Khorshid
Design Capacity (m3/d) 15,000
Actual capacity (m3/d) 6,500
Al Tankeya Al Gharbeyah
Design Capacity (m3/d) 462,000
Actual capacity (m3/d) 426,613
Abees 10
Design Capacity (m3/d) 3,000
Actual capacity (m3/d) 1,100
Al Hanoveel
Design Capacity (m3/d) 50,000
Actual capacity (m3/d) 20,000 - 30,000
Abees 2/8
Design Capacity (m3/d) 3,000
Actual capacity (m3/d) 2,000
Abees 6/8
Design Capacity (m3/d) 3,000
Actual capacity (m3/d) 1,000
Al Kilo 21
Design Capacity (m3/d) 215,000
Actual capacity (m3/d) 150,000
Abees 11/8
Design Capacity (m3/d) 3,000
Actual capacity (m3/d) - - -
Al Kilo 26
Design Capacity (m3/d) 4,000
Actual capacity (m3/d) 4,200
Escan Mubarak
Design Capacity (m3/d) 15,000
Actual capacity (m3/d) 22,000
Al Montaza
1st. Al Raml
2nd. Al Raml
Sidi Gaber
Bab Sharqy
Al Gomrok
Al Mansheya
Alexandria port
Al Atareen
Moharram Bek
Karmouz
Meena Al Basal
Al Dekheila
Al Amreyya
WWTP
Governorate Boundary
District Boundary
km

The Core Concept



الشكل يوضح العلاقة بين خصائص السيب الداخل لمحطة الصرف الصحي (كما ونوعا) ونوعية تكنولوجيا المعالجة لمياه الصرف الصحي من ناحية، وبين الحمأة المتولدة،، والتي تخضع لعمليات معالجة يتحدد بموجبها خصائص المنتج النهائي (كما ونوعا).

Alexandria Now



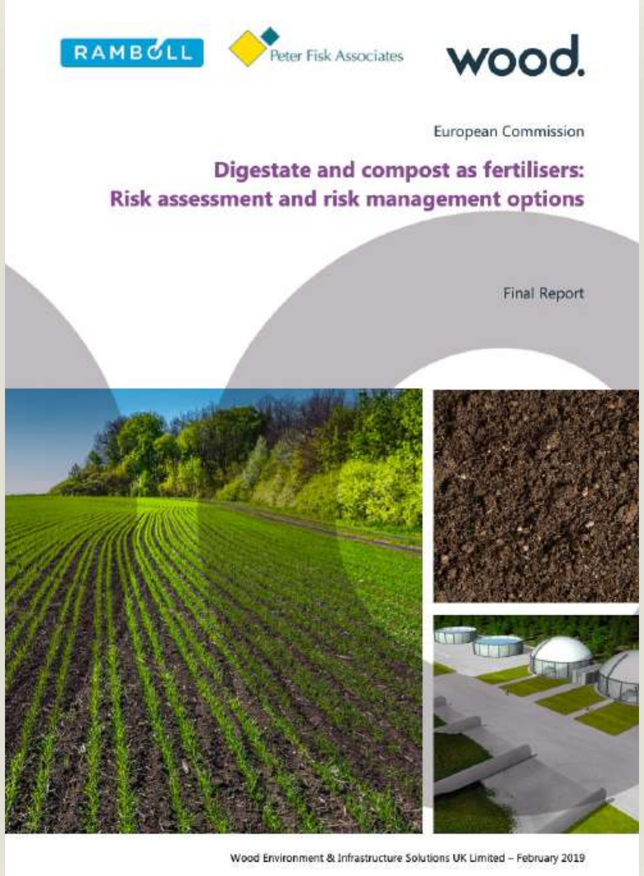
Main Issues	Description
Dewatered sludge transportation	Dewatered sludge (say 20% solids) is transported from 20 WWTPs to 9N site as centralized composting facility
Quality of product compost	Quality is monitored as per current specs, see **Reference A**
Alternative sludge valorization methods	There are a long list of technologies at various degrees of TRL for sludge valorization, see **Reference B**

Refernece A

Results

17 substance groups were identified, covering more than 94 single substances and 4 sub-groups[2], based on the information retrieved from 50 relevant publications. Based on the priority levels and discussion with the project steering group, the **following substances were then taken forward for further risk assessment**:

- Heavy metals – represented by cadmium, nickel, lead, copper, zinc and mercury.
- Bisphenol-A.
- Phthalates – represented by di(2-ethylhexyl)phthalate (DEHP).
- Pharmaceuticals – represented by 17α-Ethinylestradiol (EE2).
- Hexabromocyclododecane (HBCDD).
- Dioxins, furans and dioxin-like PCBs – represented by 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD) and 2,3,4,7,8-pentachlorodibenzofuran (2,3,4,7,8-PCDF).
- Other PCB – represented by 2,4,4'-Trichlorobiphenyl (PCB-28).
- Nonylphenol isomers and ethoxylates – represented by nonylphenol.
- Polycyclic aromatic hydrocarbons (PAH) – represented by benzo[a]pyrene, chrysene, benz[a]anthracene, benzo[b]fluoranthene and indeno[,2,3-cd]pyrene.
- Perfluoralkyl substances (PFAs) – represented by perfluoroctanesulfonic acid (PFOS) and undecafluorohexanoic acid (PFHxA).
- Physical impurities – represented by microplastics.



Refernece A

Substance	Safe limit concentration in C/D for application to agricultural land	Safe limit concentration in compost for container growing
Cadmium	*	*
Nickel	*	7.9 mg/kg dry weight
Copper	*	200 mg/kg dry weight
Zinc	600 mg/kg dry weight	70 mg/kg dry weight
Mercury	0.2 mg/kg dry weight	*
Nonylphenol	*	3.5 mg/kg dry weight
For pollutants where safe limits cannot be defined:		
Substance (group)	**Range of existing limits**	**Considered most appropriate if EU-wide limits were to be set based on existing limits**
PCBs	PCB6: 0.1-1.2 mg/kg d.m. PCB7: 0.15-0.8 mg/kg d.m.	PCB7: 0.8 mg/kg d.m.
Dioxins and furans	17 PCDD/F: 20-100 ng TEQ/kg d.m. PCDD/F + dl-PCB: 30 ng TEQ/kg d.m. for the	17 PCDD/F: 20 ng TEQ/kg d.m.
Lead	100-150 mg/kg d.m	120 mg/kg d.m.
PFAS	PFOA+PFOS: 100 µg/kg d.m.	PFOA+PFOS: 100 µg/kg d.m.
PAHs	PAH16: 3-10 mg/kg d.m. PAH11: 3 mg/kg d.m.	PAH16: 6 mg/kg d.m.

Refernece B

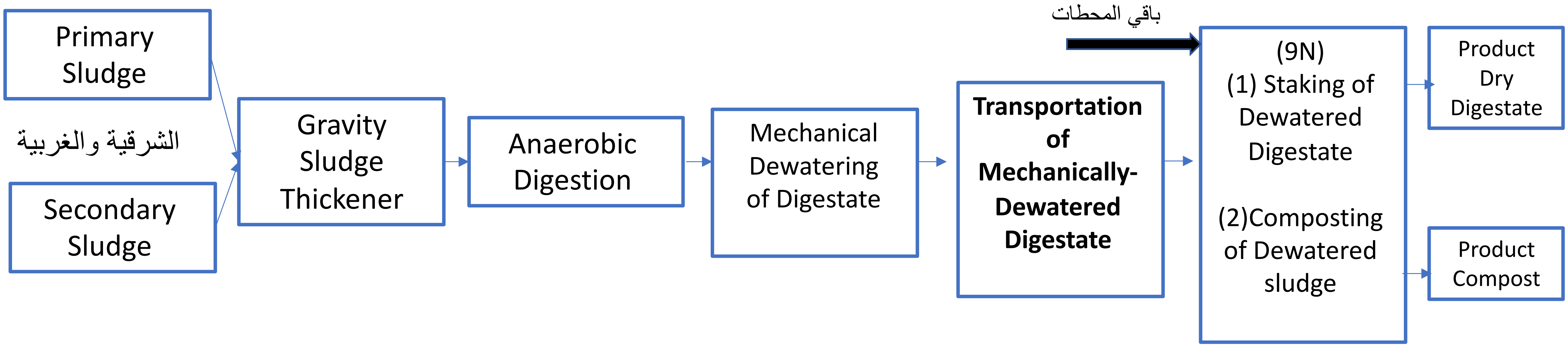
Ecological and economical balance for sludge management options

Jeremy Hall
WRc plc, Medmenham, Marlow, SL7 2HD, United Kingdom

Options	Benefits	Constraints
Sludge use options – *land based*		
• Agriculture • Reclamation • Silviculture • Forestry • Amenity • Horticulture	• Policy • Nutrients • Organic matter • Low cost/low technology	• Voluntary • Vulnerable • Variable demand • Quality • Impacts • Competition
Sludge use options – *fuel based*		
• Incineration • Supplementary fuel for power and processes • Gasification	• 'Green' energy • Transport costs (if on site) • Continuous process	• Public perception • Planning controls • Costs • Emissions • Ash disposal
Sludge disposal options – land based *(not from 2020?)*		
• Landfill - Mono - Co-disposal	• Low cost • Low technology • Fill and forget • Enhanced CH_4 recovery	• Gas emissions • Leachate • Legacy • Resource loss • Void loss
Sludge disposal options – water based *(not from 31/12/98)*		
• Surface waters	• Low cost • Low technology • Biological productivity • CO_2 fixation	• Contaminants • Nutrients • Perception

Source: https://ec.europa.eu/environment/archives/waste/sludge/pdf/workshoppart4.pdf

Alexandria, Near Future



Main Issues	Description
Dewatered digestate transportation	Same as dewatered sludge
Quality of stacked digestate product	See **reference A**
Alternative digestate valorization methods	See **reference C and D**

Refernece C

Waste and Resources Action Program ("WRAP")

Waste & Resources Action Programme

Project code: OMK006-002

Digestates from Anaerobic Digestion: A review of enhancement techniques, and novel digestate products

wrap

Information sheet

Review: Technologies to optimise the value of digestate (2020)

Technology	Short description	Prior Status[1]	Current Status	Examples	Stage[2]
WRAP "Optimising the value of digestate and digestion systems" short list					
Neo Energy (organic based fertiliser)	Uses excess heat together with electricity from a combined heat and power system to dry the digestate to a granular form. (WRAP, 2015)	The process has been commercialised in certain markets (U.S.) with granules being marketed to golf courses as a high value material offering a range of benefits. The interest around Neo Energy is not the technology itself rather the innovative marketing surrounding the product.	Difficult to determine the success of Neo Energy in the U.S and there is no immediate evidence to suggest that such a product has been marketed successfully in the UK. Digestate pelleting lines have been set up by organisations in the UK. However, although the technology appears available at larger scale there is still little evidence of up-scaling or successful case studies.	PRM Waste Systems UK Kesir Dorset – Green machines	**Commercial**
Hydrothermal Carbonisation (HTC)	Takes wet/dry biomass and applies heat and pressure to convert it into dry, black powder (biocoal/biochar). This reduces the weight of the digestate and adds value to both the digestate and feedstock.	The process was deemed very close to market by the work covered in the original WRAP report. However, there were concerns over the interaction between water within the digestate and heat and pressure required during the process.	No studies had been found to suggest HTC had undergone a Cost-Benefit Analysis. However, organisations were identified who offered such technology (Antaco, TerraNova Energy). The Incover EU project also aimed to validate and demonstrate HTC technology to produce bio-coal. The project determined the process has a technology readiness level (TRL) of	Incover Project EU TerraNova Energy Antaco	**Commercial**

Boerger Bioselect separator	Digestate flows through the Bioselect vessel through a sealed slotted screen, which separates the outer vessel from an auger chamber. The liquid then filters through the screen to the outer vessel. The liquid phase is discharged whereas the solid particles remain in the filter area where they are conveyed by a rotating auger unit to a post-press channel. It has been applied to digestates treating from 6 to 15% dry solids and achieving up to 35% dewatered fibre.	This is a fully commercial process that is already being utilised at a full-scale and thus needs no funding to take it to marketplace.	No expected change since 2015.	https://www.boerger.com/en_UK/our-company.html	**Commercial**
Advetec biothermic digester	This digester accepts mixed waste streams such that multiple materials can all enter the reactor along with the organic material. The process is an aerobic one and claims to exploit extremophilic bacteria. The	Although the biothermic digester was awarded the Zero Waste award in 2014 from Organics Recycling, it is not clear that this process generates a useful product. Although the organic fraction and water appear to be, removed the	This company seems to be expanding. Still seems to be a modular setup rather than large volumes like in AD plants, but this company is ideal for small to medium-scale volumes.	Advetec – case studies	**Commercial**

Additional technologies					
Thermal dewatering post-AD	The process of undertaking thermal dewatering after the AD process has occurred.	N/A	A Norwegian study (Svennevik et al. 2019) – found that dewatering after AD increased the dry solids content by 87% on average (from a sample of 32). Samples included a range of biowaste including sewage sludge, sewage and food waste, sludge wine industry, pulp, fish waste.	-	**Pre-commercial**
Solid State Fermentation (SSF)	SSF is the biodegradation of solid organics into value products such as enzymes, biosurfactants or bioplastics.[4]	N/A	Results from the EU DECISIVE Project showed that biopesticide production from digestate using SSF appeared promising. Biopesticides have a high market value.	Biowaste valorisation in a future circular bioeconomy	**Pre-commercial**
Nitrogen Removal / Ammonia Stripping	The process of removing nitrogen, usually in the form of ammonia, from digestate or wastewater.	N/A	Many forms of nitrogen removal are fully commercialised. Dependent on the approach adopted.	AMFER ANITA ANAMMOX BYOFLEX DeAmmon	**Commercial**
Acidification	Lowering the pH of slurry has shown to reduce the levels of ammonia. When the pH drops	N/A	Used predominantly in Denmark, where it was shown that acidified	Why is acidification a success only in Denmark?	**Commercial**

GENIUS and Re-P-eat	Digestate is separated into a solid and a liquid fraction by means of a decanter. The N-rich liquid fraction will be processed into a nitrogen-potassium concentrate and clean water through a combination of DAF and membrane filtration system. Following decanting of digestate. The P-rich solid fraction will be treated with a P-stripper called "Re-P-eat" through a process of acid (H_2SO_4) and base $Ca(OH_2)$ addition. The products of this process will be mineral calcium phosphate (CaP) and a P-poor organic soil conditioner.[7]	N/A	Digestate volume is reduced. Only small volumes of concentrated minerals need to be transported or applied on fields, leading to reduction of digestate transport cost over long distances. During year one of the SYSTEMIC project major progress has been made on the engineering and optimisation of the RePEat process based on experiences gained at the pilot installation and additional laboratory tests. The process has been further optimized based on new insights after market research.	Groot Zevert Vergisting (Beltrum, NL)	**Commercial**
Fertiliser production	CCm Technologies has developed a method of producing fertiliser and soil conditioner through the use of captured carbon dioxide from industrial power generators. The first full-scale fertiliser manufacturing plant has been successfully commissioned at CCm's Technology Centre in Swindon before its deployment to	N/A	CCM are moving slowly from a developmental technology to deployment in the UK water industry with plants established in two water companies. Web quote Transformation of 6,500 tonnes of waste Anaerobic Digestate cake into approx. 13,000 tonnes of high-grade compound fertiliser. Exothermic heat (1.98 GJ (551kWh) of thermal energy per tonne of carbon dioxide; high storage density	CCm Technologies	**commercial**

Refernece D

17th European Biosolids and Organic Resources Conference

UNWRAPPING THE MYSTERY OF DIGESTATE ENHANCEMENT

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Pell Frischmann Consultants
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Abstract

To support the delivery of a number of actions contained in the AD Strategy and Action Plan (June 2011) and the delivery of Scotland's Zero Waste Plan(2010) WRAP commissioned Pell Frischmann to undertake a review of digestate enhancement technologies.

This paper reviews the work completed under WRAP Contract OMK006-002. The study considered both non-waste and waste-based digestates, mixed-waste digestates as the output from Mechanical Biological Treatment, sludge digestates and co-digestates from feedstocks including sewage sludge.

The key aim of the study was to raise awareness in the UK Waste Sector to opportunities for enhancing digestates in advance of significant planned growth of anaerobic digestion facilities in the UK.

Referenece D

Table 1: Post-Digestion Enhancement Techniques

Physical	Thermal
Thickening (Belt)	Drying (Rotary Drying)
Thickening (Centrifuge)	Drying (Belt drier)
Dewatering (Belt press)	Drying (J-Vap)
Dewatering (Centrifuge)	Drying (Solar)
Dewatering (Hydrocell)	Evaporation (scraped surface heat exchangers)
Dewatering (Bucher press)	Conversion (Incineration)
Dewatering (Electrokinetics)	Conversion (Gasification)
Purification (Ultrafiltration and Reverse Osmosis)	Conversion (Wet air oxidation)
	Conversion (Pyrolysis)

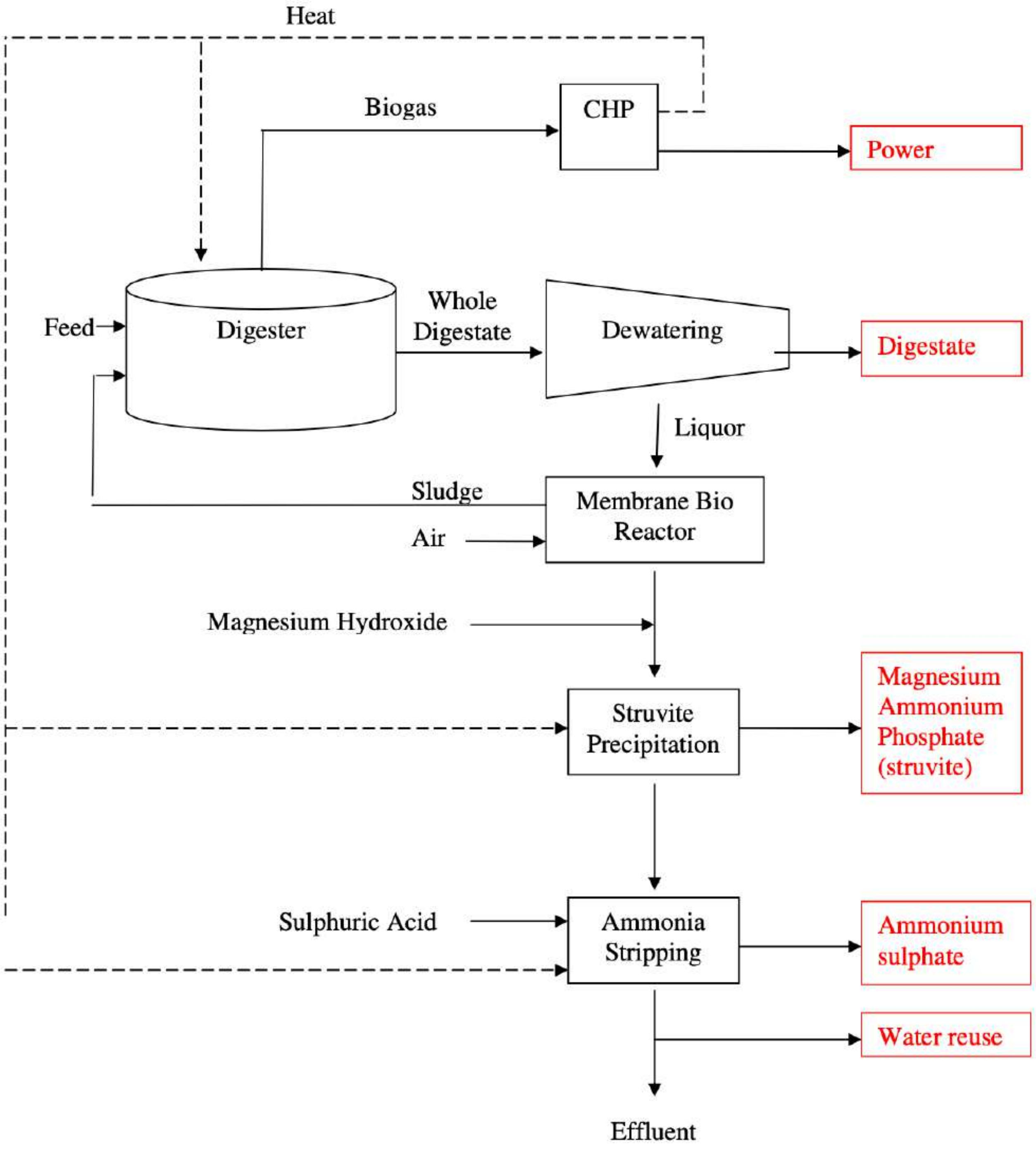
Refernece D

Biological	Chemical
Composting	Struvite precipitation
Reed Beds	Ammonia recovery (Stripping + Scrubbing)
Biological Oxidation	Ammonia recovery (Membrane Contactor)
Biofuel Production (Algae)	Ammonia recovery (Ion Exchange)
Biofuel Production (liquor as process water)	Acidification
Biofuel Production (hydrolysis of fibre to Bioethanol)	Alkaline Stabilisation
Microbial Fuel Cell	

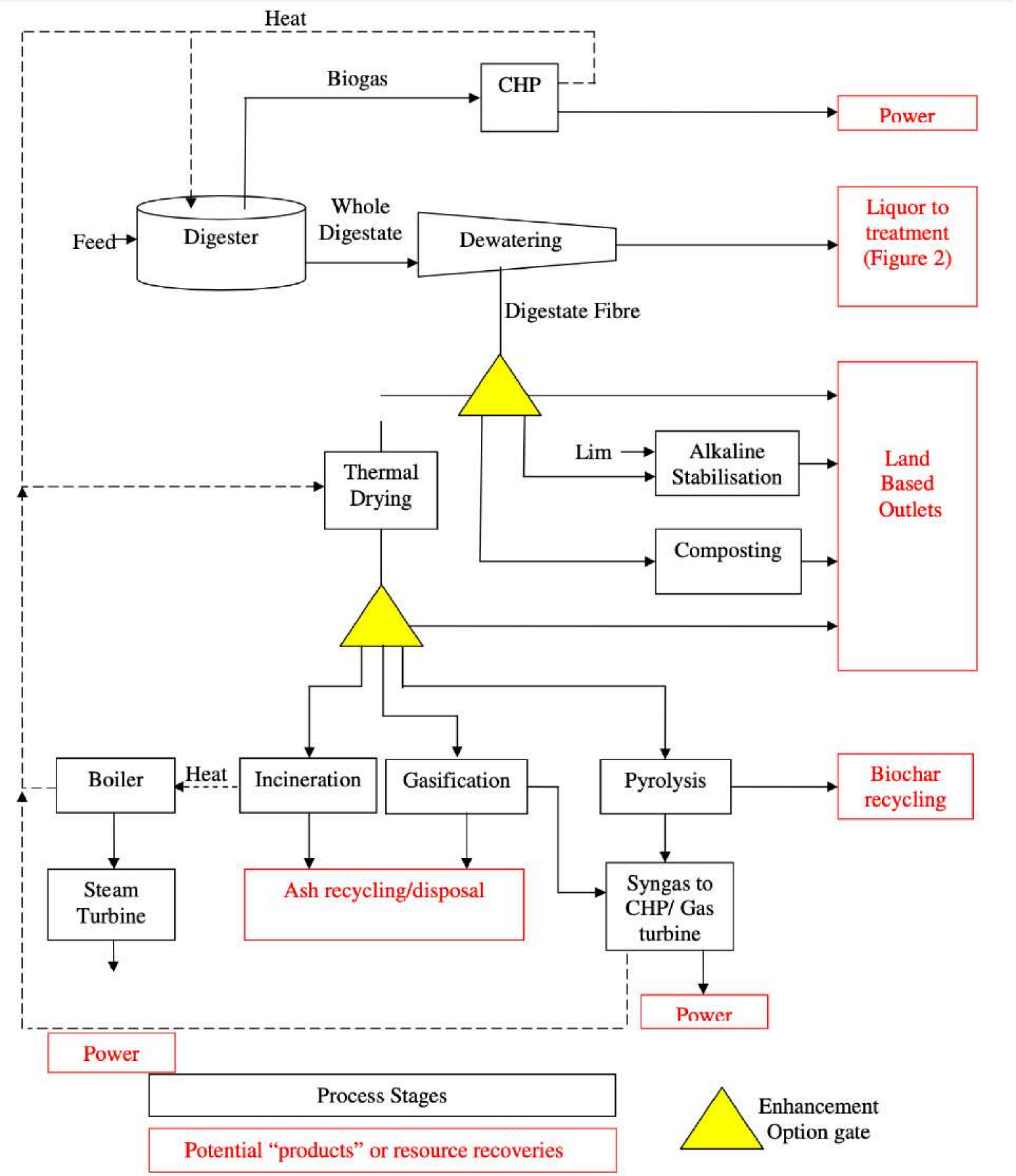
The digestate contains significant quantities of nitrogen, phosphorus and potassium and typical values are summarized as follows:

- Nitrogen: 2.3 - 4.2 kg/ton
- Phosphorous: 0.2 - 1.5 kg/ton
- Potassium: 1.3 - 5.2 kg/ton

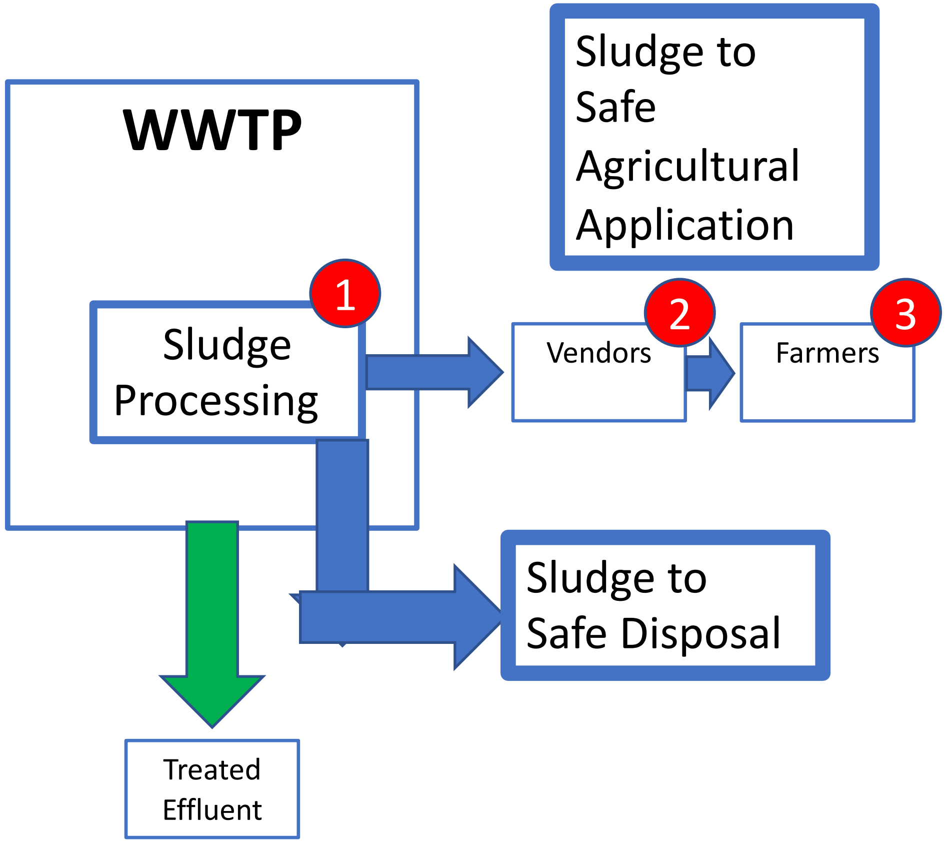
Valorization of Digestate Liquor



Valorization of Digestate Fiber



التخلص الآمن من الحمأة غير المطابقة



يتطلب التخلص النهائي من الحمأة غير المطابقة بطريقة آمنة

١. نظام للتحاليل لتحديد كميات الحمأة المطلوب التخلص الآمن منها

٢. نظام لنقل الحمأة غير المطابقة الي موقع التخلص

٣. نظم التخلص الآمن

أ. بالحرق

(الحرق في محارق أو في مصانع الأسمنت)

ب. الدفن الصحي

وفق استراتيجية إدارة المخلفات الصلبة البلدية ، سوف يتم انشاء عدد ٥٠ مدفن صحي. ومن الأهمية بمكان التنسيق مع وزارة البيئة لعمل خلية في مدفن صحي بمواصفات تمكن من دفن الحمأة غير المطابقة.

أهداف استراتيجية إدارة الحمأة علي المستوي القومي

Operational Objectives:
1. Sludge volume reduction
2. Sludge quality improvement
3. Beneficial recycling maximization

1. تطوير نظم تداول ومعالجة الحمأة في المحطات القائمة
2. تطوير نظم تشغيل وصيانة عمليات تداول ومعالجة الحمأة في المحطات القائمة
3. تطوير التطبيقات الحالية للحمأة المنتجة
4. تطبيق نظم متطورة لتداول ومعالجة الحمأة في المحطات الجديدة
5. حل المشاكل المتعلقة بنظم التخلص النهائي للحمأة غير المطابقة

الاستراتيجية ١	توفير متطلبات تحقيق الكفاءة والفعالية في إدارة الحمأة وترشيد استخداماتها من خلال الدعم الفني المقدم من الشركة القابضة للشركات التابعة
التوصيف	سوف يت ... للشركة القابضة • الاش ... ـعة، وتطو ○ ... ـب ○ ... علي ○ ○ • تنفيذ البر • تنفيذ مكون التقييم والمتابعة • توفير الاستثمارات المطلوبة
الارتباط مع الأهداف	الأهداف ١-٥

١٢٨

أ. تحويل جميع المحطات التي تزيد طاقتها عن ٢٠ ألف متر مكعب/اليوم الي منظومة انتاج الطاقة والسماد السائل من خلال عقود مشاركة القطاع الخاص

١٣٢

ب. تحويل جميع المحطات التي تقع طاقتها بين ٥-٢٠ مكعب/اليوم الي منظومة انتاج الكمبوست

١٤٤

ج. تحويل جميع المحطات التي تقل طاقتها عن ٥ ألف متر مكعب/اليوم الي محطات معالجة الحمأة (مركزية) تطبق الحل (أ) أو (ب)

اعتبارات تكنولوجية

1. التحول الي انتاج الطاقة أ : المحطات بدون صرف صناعيElectrical energy
2. التحول الي انتاج الطاقة ب : المحطات بصرف صناعي Alternative fuels
3. التحول نحو تكنولوجيات جديدة مثل الطاقة الشمسية في تجفيف الحمأة أو استخدام Geobags
4. التحول نحو تطبيقات جديدة للحمأة المنتجة مثل بدائل الوقود الصلب لمصانع الأسمنت
5. استخدام تكنولوجيات ملائمة لاستيفاء متطلبات الصحة العامة (مثل إضافة الجير الحي lime stabilization)

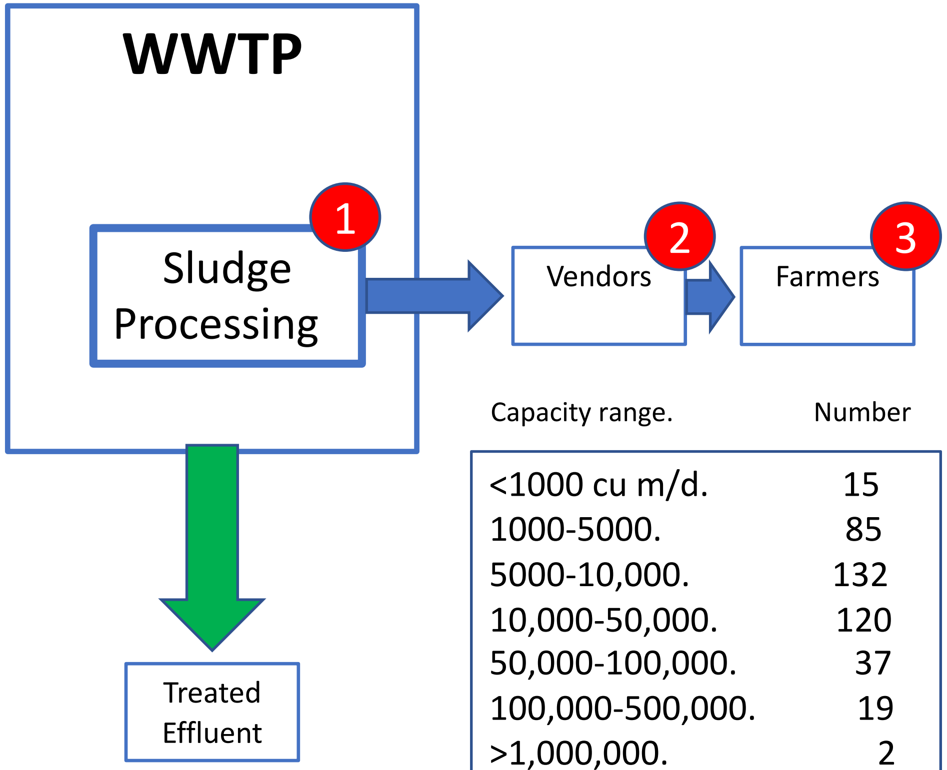
ملحق : الخلفية

من العرض الخاص بالاستراتيجية القومية لإدارة الحمأة

الخلفية ١

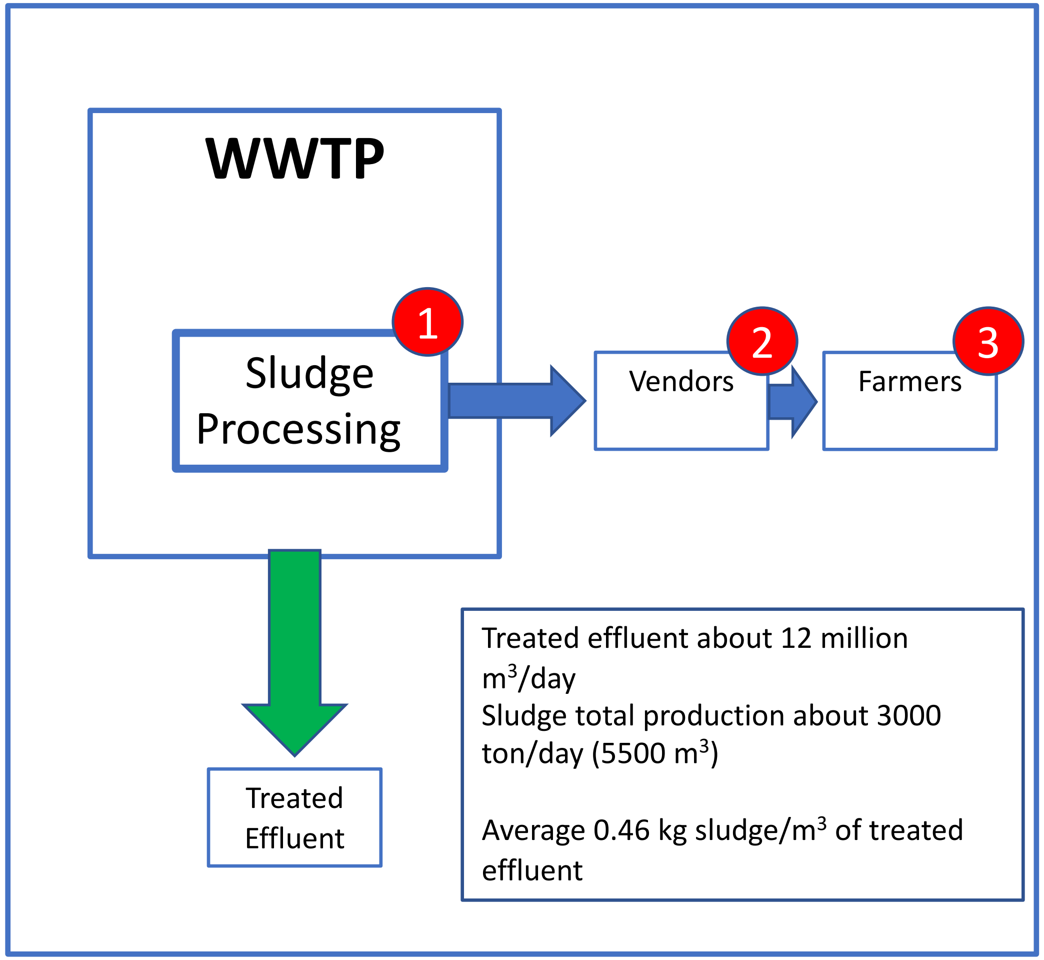
تقدر كمية الحمأة التي تنتج يوميا من جميع المحطات القائمة بحوالي ٢٩٠٠ طن (المكافئ الجاف) منها حوالي ٤٠٠ طن من القاهرة و ٣٠٠ طن من الإسكندرية.

يتم التعامل مع الحمأة داخل محطات الصرف الصحي 1 وفق نظام متشابه في معظم المحطات باستخدام أحواض التجفيف الطبيعية، وتباع الحمأة المنتجة الي مقاولين 2 ، والمفترض أن يتولوا تخزين الحمأة قبل بيعها للمزارعين 3 لمدة ٦ أشهر.



Capacity range.	Number
<1000 cu m/d.	15
1000-5000.	85
5000-10,000.	132
10,000-50,000.	120
50,000-100,000.	37
100,000-500,000.	19
>1,000,000.	2

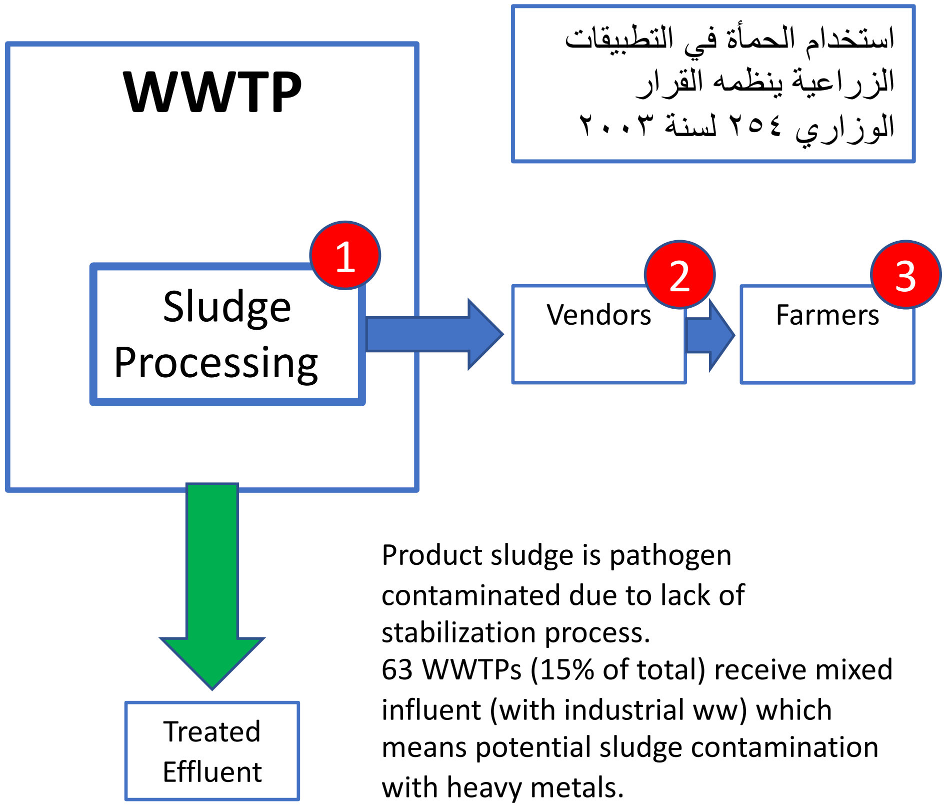
الخلفية٢



Sludge Processing: 1

- Primary and secondary sludge is thickened in gravity thickeners to 4-6% dry weight
- In sand drying beds, after 2-3 weeks drying cycle in summer (or 6-8 weeks in winter), sludge is supposed to reach 40-50% dry weight.

الخلفية٣



Product sludge is pathogen contaminated due to lack of stabilization process.
63 WWTPs (15% of total) receive mixed influent (with industrial ww) which means potential sludge contamination with heavy metals.

Vendors: 2

Dried sludge is sold to vendors at a price of LE 50-100/cu m.

The vendors are obliged to store the sludge up to 6 months prior to use in agriculture.

Liability Transfer

Farmers: 3

Vendors sell the sludge to farmers via a non-controlled supply chain.

Farmers are obliged not to use the sludge for edible vegetables and fruits.

المسائل الأساسية

1. المسائل المرتبطة بتطوير نظم تداول ومعالجة الحمأة في المحطات القائمة
2. المسائل المرتبطة بتشغيل وصيانة نظم تداول ومعالجة الحمأة في المحطات القائمة
3. المسائل المرتبطة بتطبيق نظم جديدة لتداول ومعالجة الحمأة في المحطات الجديدة
4. المسائل المرتبطة بالتطبيقات الحالية للحمأة المنتجة
5. المسائل المرتبطة بالتحول نحو تطبيقات جديدة للحمأة المنتجة
6. المسائل المرتبطة بنظم التخلص النهائي للحمأة غير المطابقة

مراجع هامة

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Wastewater Technology Assessment

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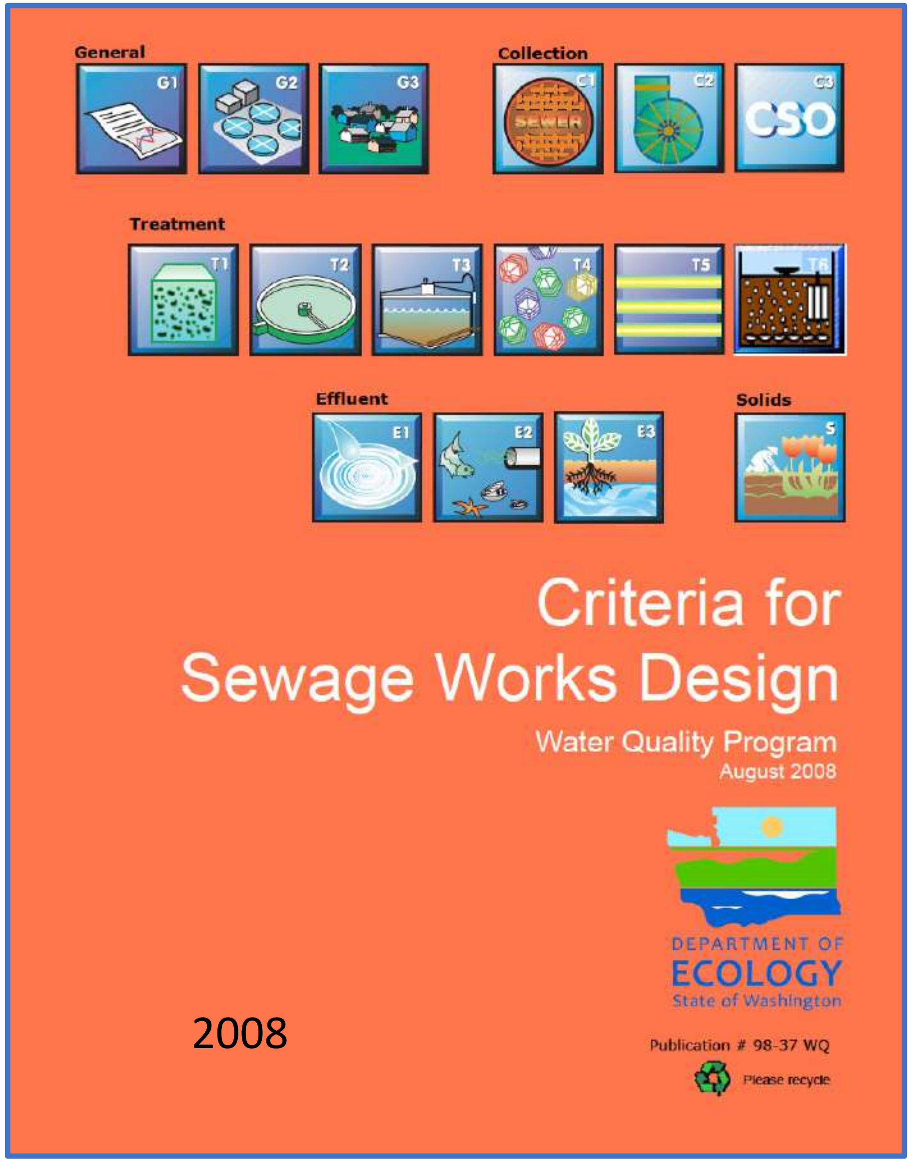

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