SIXTH FRAMEWORK PROGRAMME

Neptune FP6 Project

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Sustainable sludge handling

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The problem

- In the coming years it is expected that in Europe, at least for large wastewater treatment plants (WWTPs), the only possible solution for sludge disposal will be transforming sludge into inert material by thermal processes.
- The present European landfill Directive 99/31 has restricted this disposal route, which was practically abandoned in those countries where the implementation of the above criteria in national legislations was very stringent (a limit of the organic carbon to 4-5 % in the wastes to be disposed off is fixed).
- Guidelines for agricultural utilisation will become progressively more stringent due to increasing health concerns about the widespread diffusion of pathogen and organic micropollutants in the environment (European Commission, 2000).
- Agricultural utilisation involving large amounts of sludge to be spread on land does not seem feasible for the following reasons:
  - need of large extensions of fields and therefore long distances to be covered from WWTPs to the site of spreading;
  - need of large storage volume required when sludge cannot be used (winter periods and when the fields are flooded);
  - large WWTPs are often polluted by non controlled industrial discharges that might hinder agricultural utilisation of resulting sludge.

The problem

- The volume of the sludge extracted from primary and secondary settling tanks is about 2% of the volume of treated wastewater (WW) but its treatment and disposal entails very high capital and operating costs, which can be accounted as high as 50% of the total costs of the WW treatment plant, i.e. 25-35 €/(person × year).
- Typical treatments for a large WW treatment plant include a first phase of concentration, generally carried out by gravity thickening, a biological aerobic or anaerobic stabilization, aimed to reduce biodegradable solids, odours and pathogens, and mechanical dewatering by centrifugation, belt-pressing or filter-pressing.
- Often sludge processing is designed according to conventional systems, which might not be suitable for producing sludge with proper characteristics for the final outlet according to the legislative standards and avoiding any detrimental effects for the environment and any risk for the human health.
- According to the European Water Supply and Sanitation Technology Platform (WSSTP) *in the large majority of cases, soil is, regardless of the technology or methodology selected, the final destination of vast quantities of treated sludge*.

Current disposal options in Europe (% of sludge produced)

	Landfill sites	Thermal treatments	Composting	Agricultural utilisation	No agriculture	Other
European Union	18	23	7	45		7
Austria		35	50	15		
Bulgaria	100			Some cases		
Czech Republic	13	<1	50	17		20
Finland			73	3		
Flanders		88			12	
Germany	3-6	20 (mono-inc.)+17 (other thermal treatments)		32	25 (landscaping)	
Hungary	60	0.8		39		
Netherlands		58 (mono-inc. + 27 (drying)	15			
Norway	7			65	12	16
Slovenia	30	47 (export to incineration)	15	7		1
U.K.	1.5	19.5		67	5.2	1.8

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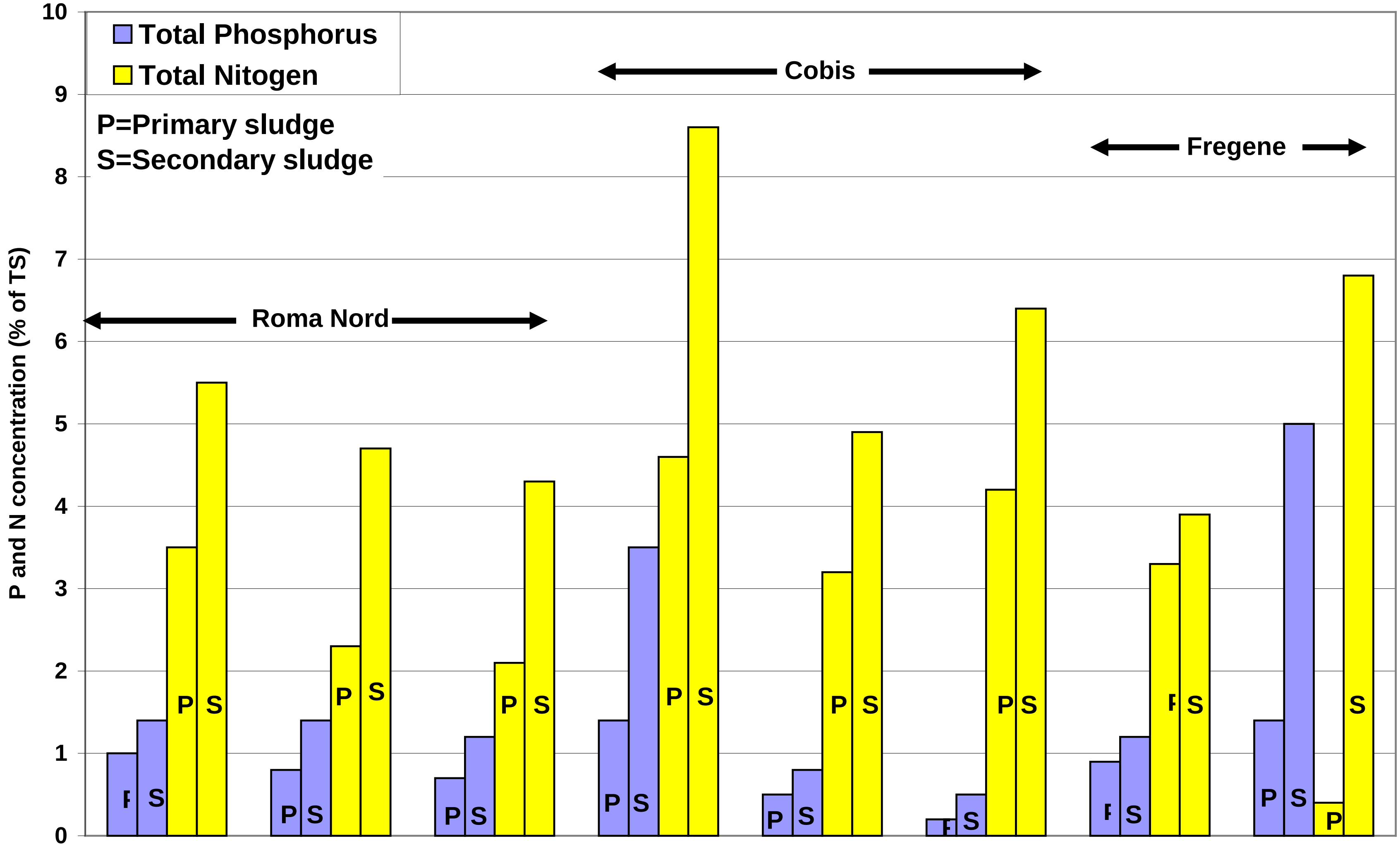
Per capita sludge production g/(person × d)

	Sludge production g/(person × d)
Austria	55
Brazil	33
Canada	76
Italy	38
Finland	94
Hungary	48
Portugal	60
Slovenia	20
Turkey	60
Medium value	54

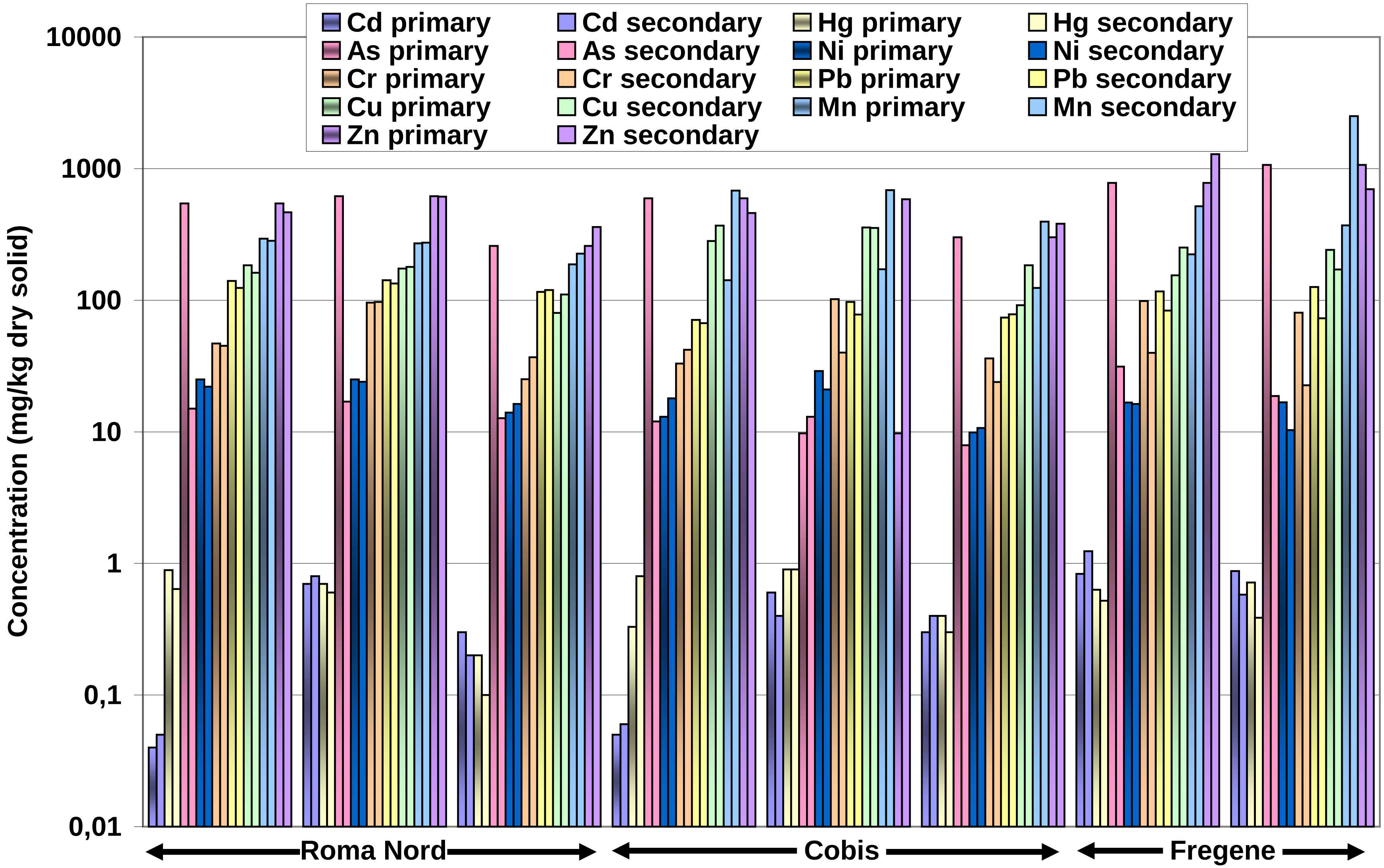
Towards a more sustainable sewage sludge management

- A more sustainable sewage sludge management could be attained through a separation of primary and secondary sludge before their treatment and disposal. It would thus be possible to maintain agricultural utilisation for the biological sludge (secondary) and to convert to inert material by incineration (on-site or off-site) only the primary sludge (Mininni et al. 2004).
- Characteristics of primary and secondary sludge are quite different in terms of quality (pollutants and nutrients) and in terms of suitability for thickening, digestion and dewatering. Secondary sludge is expected to be less polluted than primary sludge, and should be segregated and treated separately from primary sludge thus sustaining its agricultural utilisation.
- Sludge separation may also give flexibility to sludge management, decreasing dependency on conventional disposal options (as required in the European Directive 2008/98) as sludge of good quality (biosolids) can be recovered for agricultural utilisation while the remaining primary sludge can be treated by thermal treatments. The challenge in the coming years will be, in fact, assuring in sludge management the greatest flexibility, maximizing recovery of valuable products and energy sources and reducing disposal only to inert materials which cannot be recovered any more.

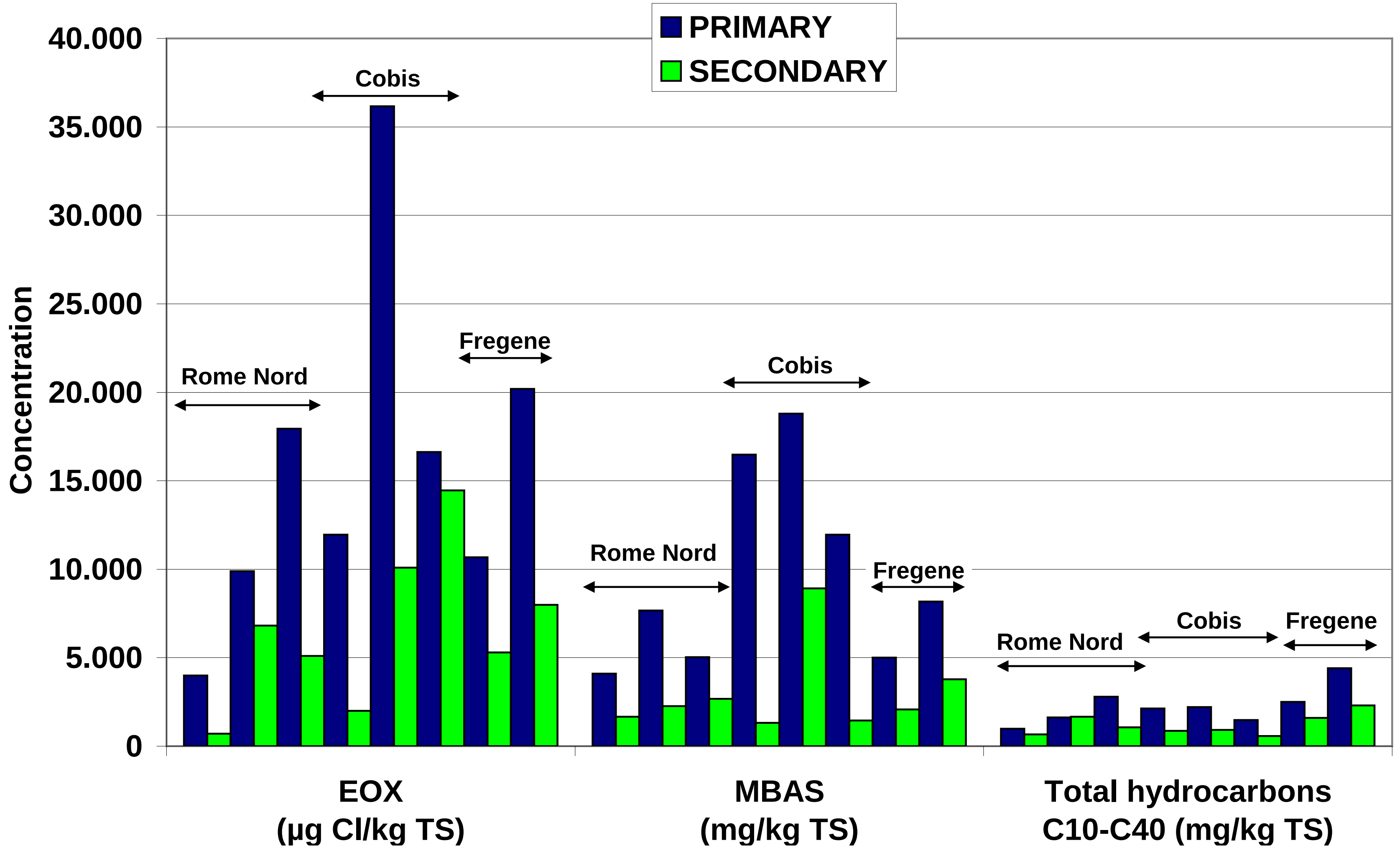
Assessment of primary and secondary sludge characteristics in the Neptune project (nutrients)



Assessment of primary and secondary sludge characteristics in the Neptune project (metals)



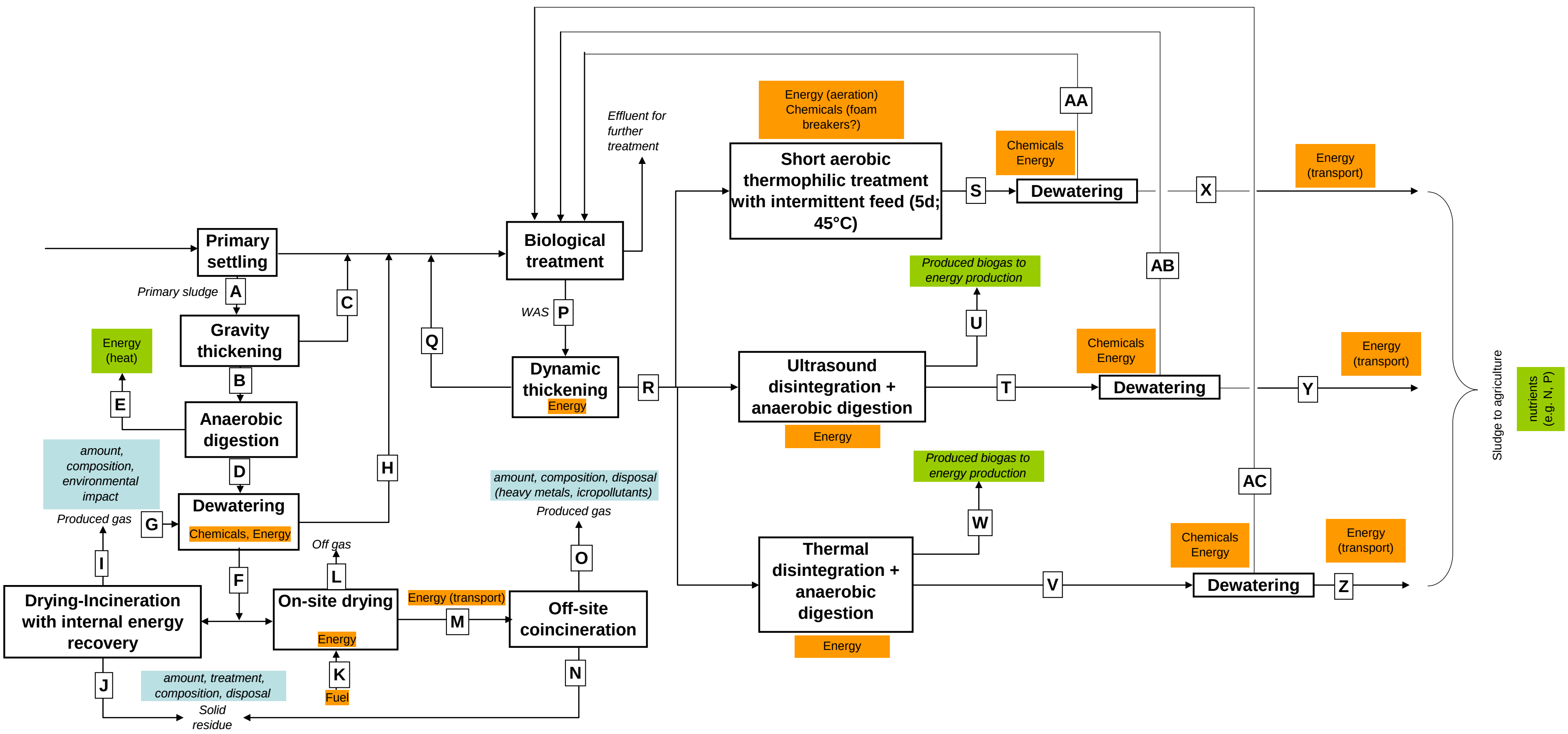
Assessment of primary and secondary sludge characteristics in the Neptune project (organic micropollutants)



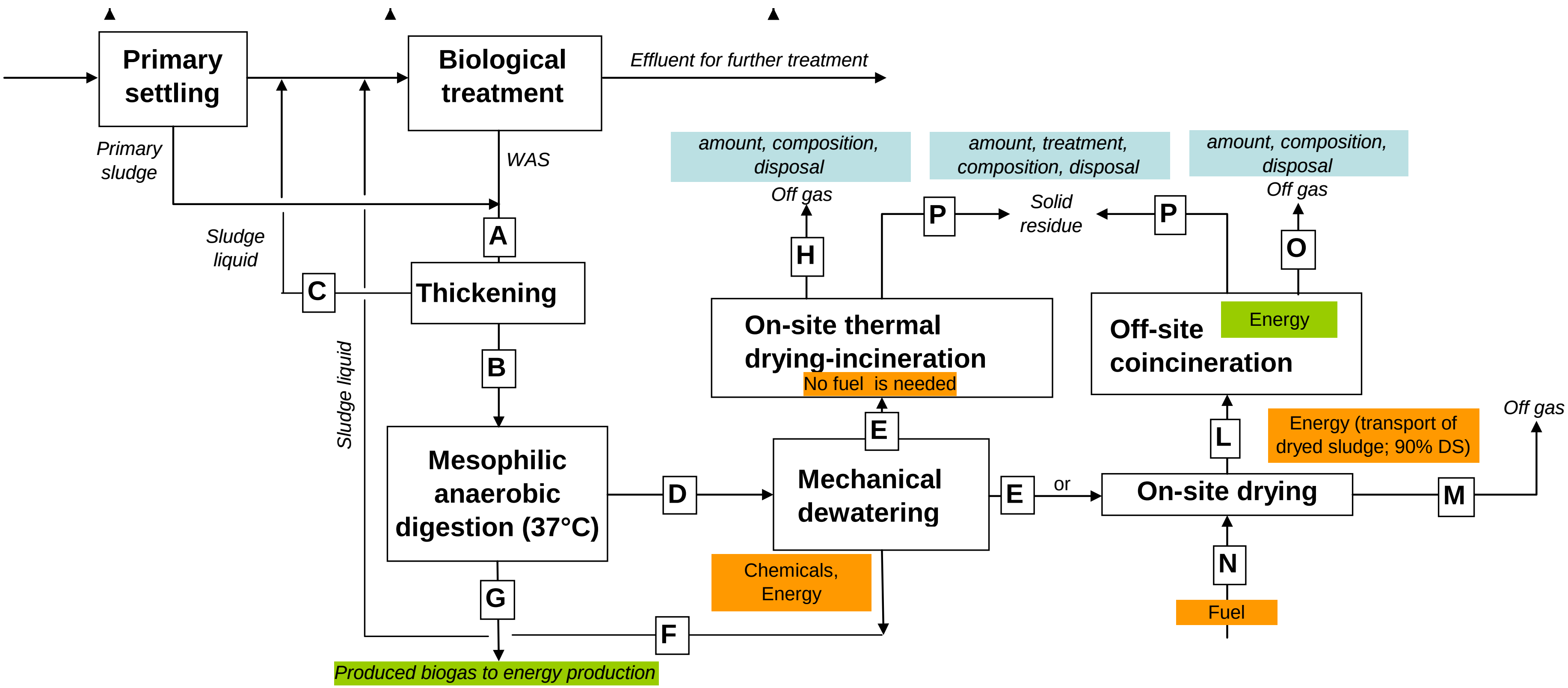
Secondary sludge disintegration

- One of the main goals in secondary sludge processing is improving the performance of the anaerobic digestion.
- Secondary sludge contains up to 70% of bacteria which can be resistant to anaerobic digestion.
- Acceleration of the process can be achieved by increasing the hydrolysis, which is the limiting step of the whole anaerobic process.
- Sludge disintegration treatments are able to disrupt biomass flocs and cell walls and to cause the release of the intracellular organic material. The subsequent increase in biodegradable material improves bacterial kinetics resulting in lower sludge quantities and, in the case of anaerobic digestion, increased biogas production.
- The most common methods for sludge disintegration are based on the use of ultrasounds (mechanical disintegration) at an energy input of 1-2 kWh/kg dry solids or on thermal disintegration at temperature of 170°C and 8.5 bar (Cambi process) or at 150-180°C and 8-10 bar (Biothelys process).

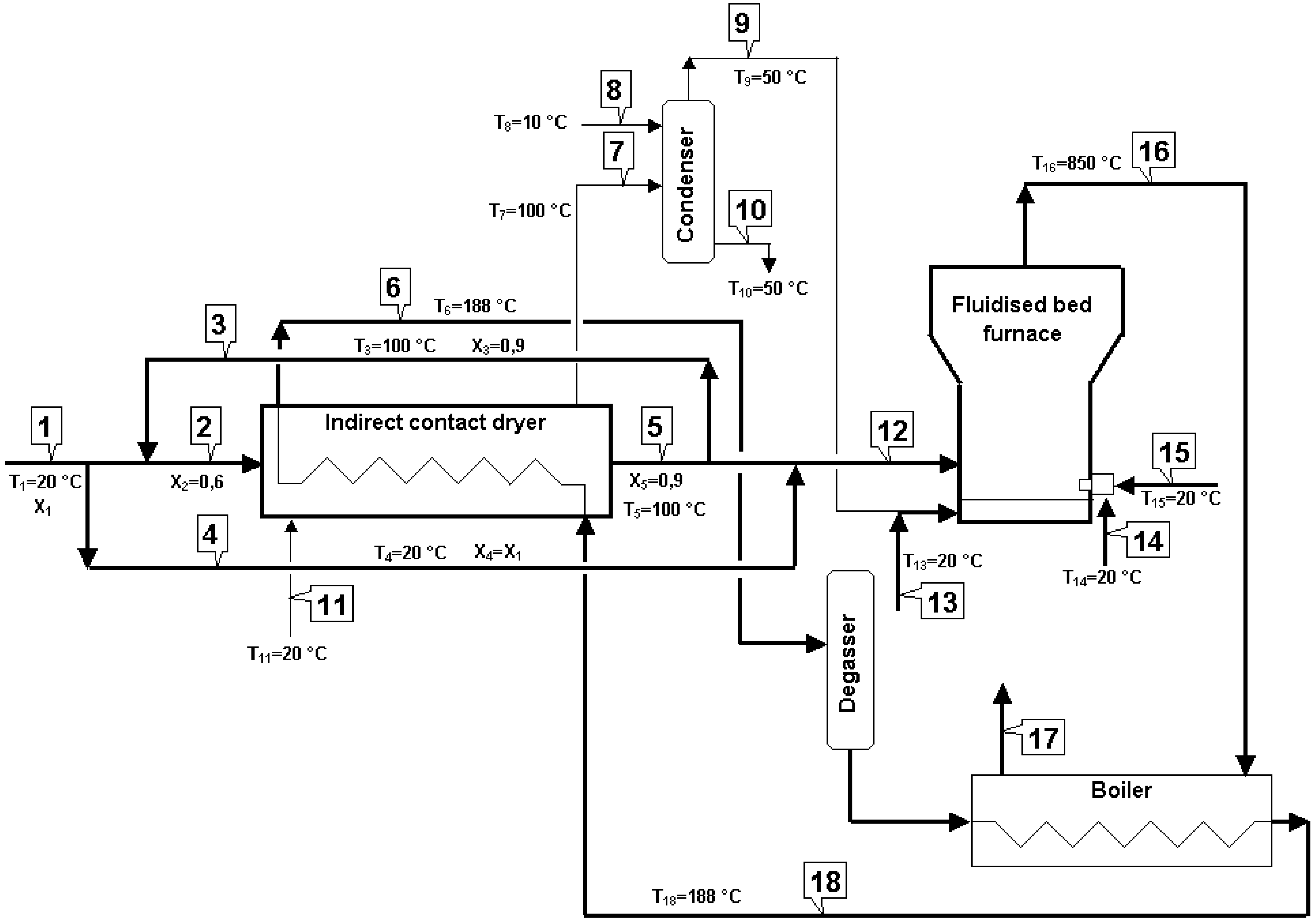
Process flow sheets with sludge triage



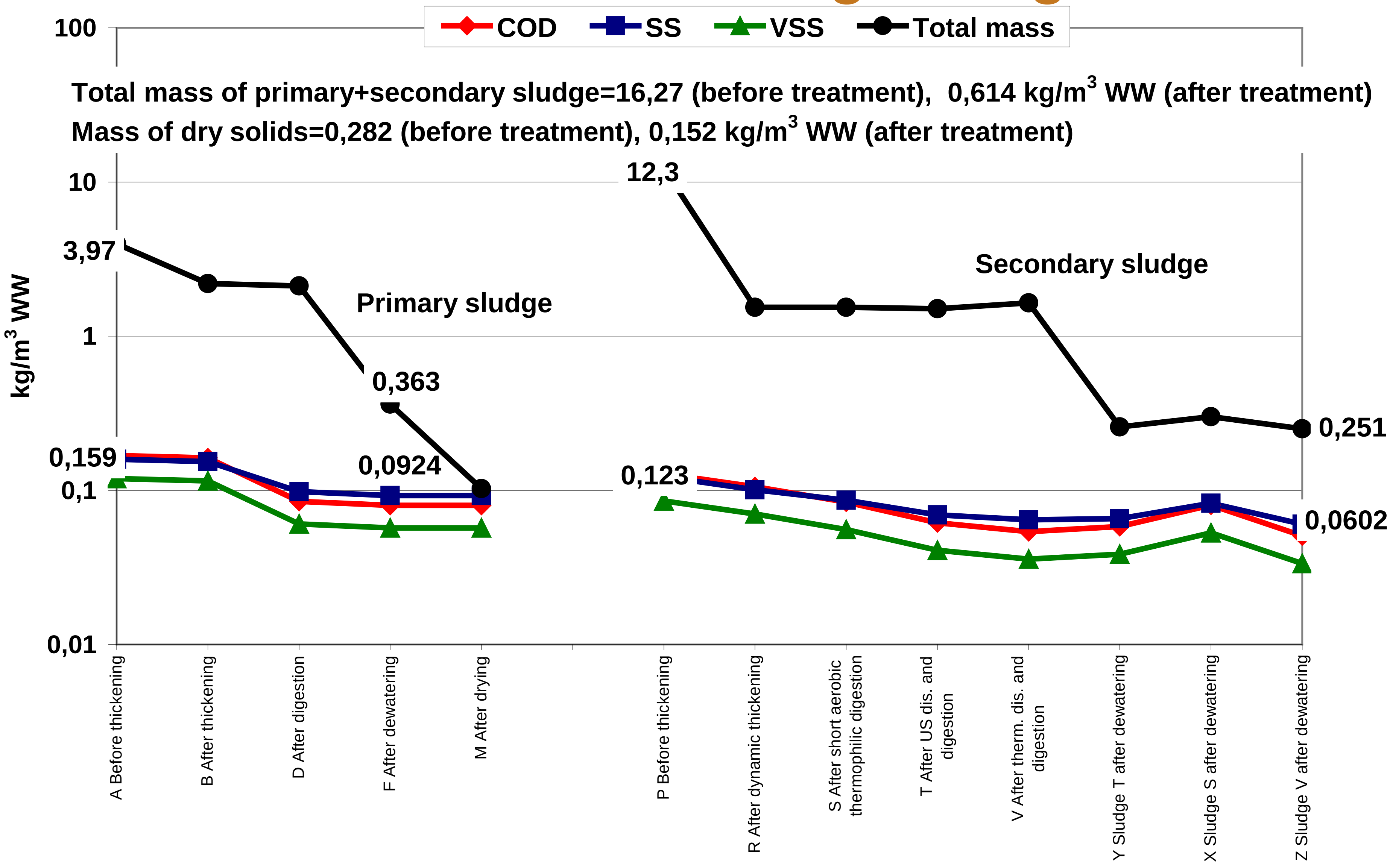
Process flow sheets without sludge triage



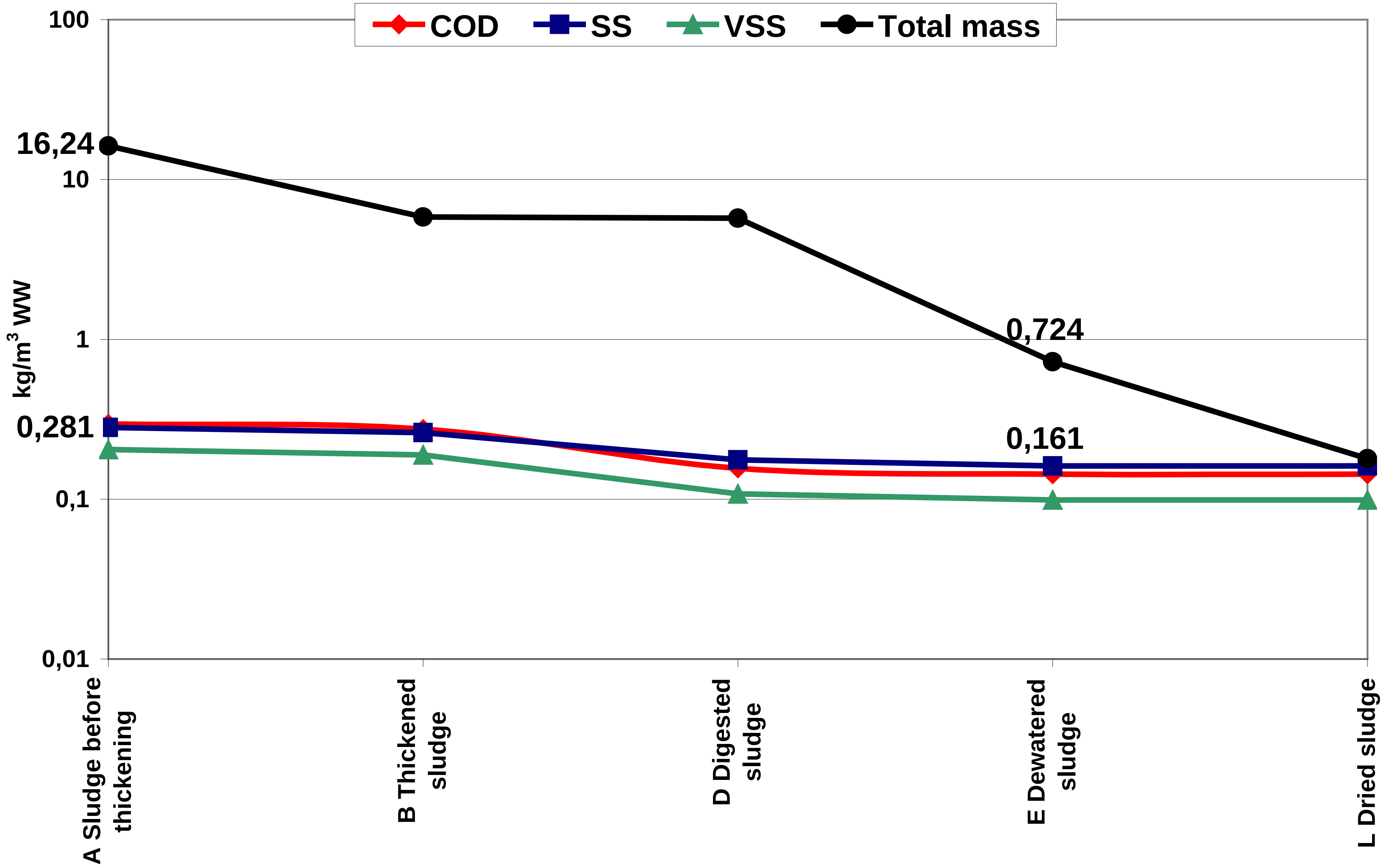
Flow sheet for sludge incineration



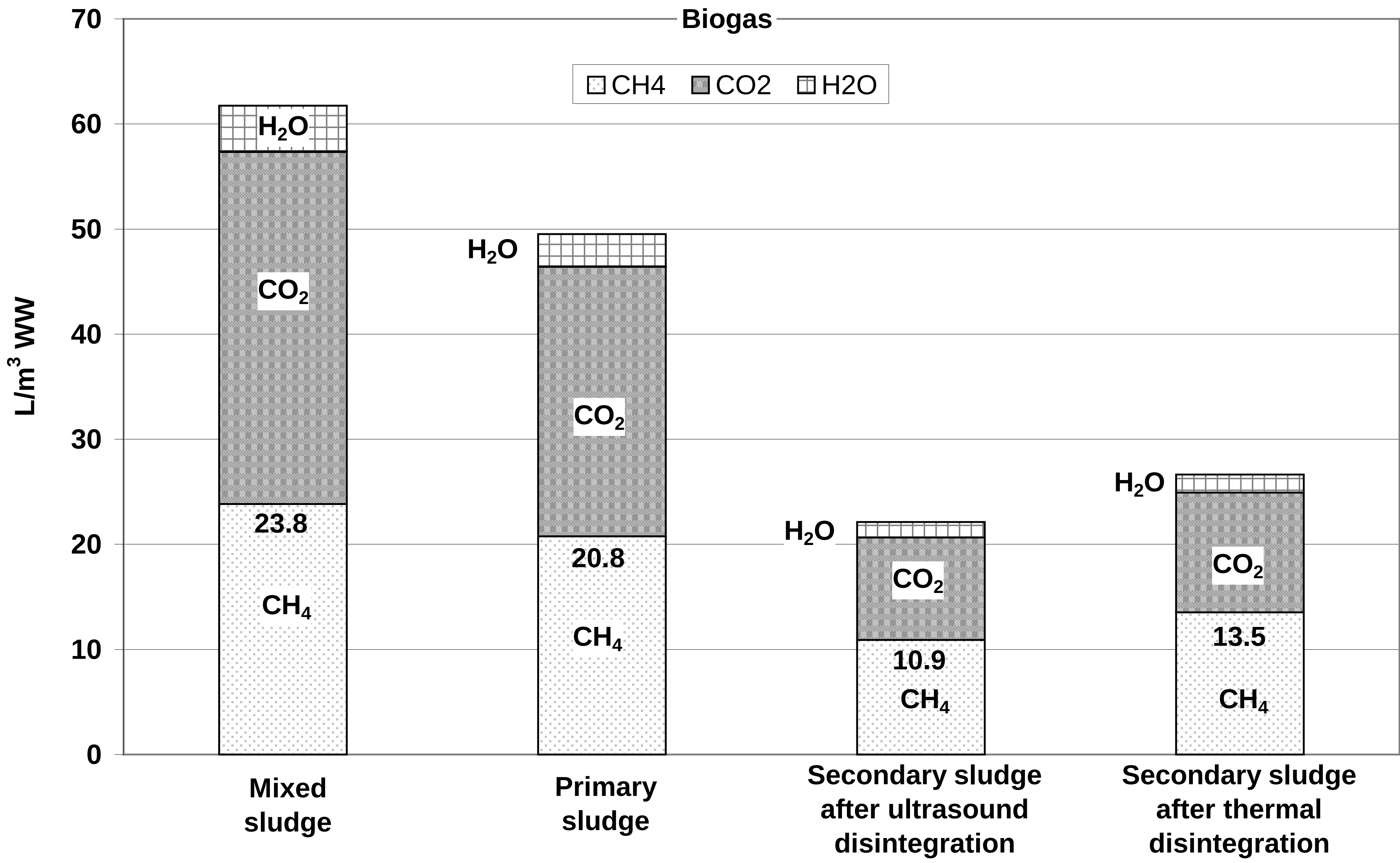
Results with sludge triage



Results without sludge triage



Net biogas production



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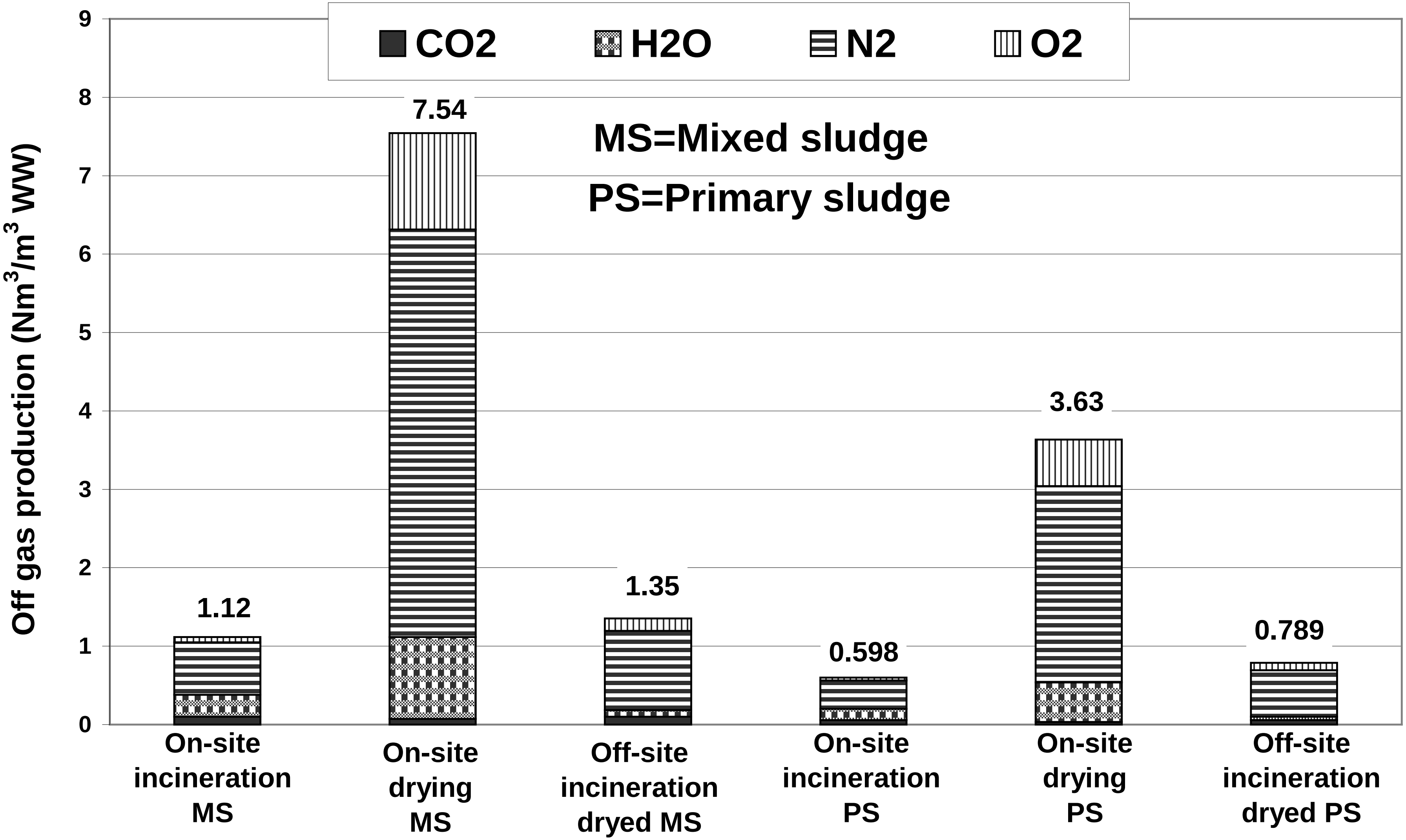
Off gas from thermal treatments



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Conclusions

- Sludge triage allows:
  - reducing the production of primary + secondary sludge with respect to conventional treatment, considering that secondary sludge can be appropriately treated by dynamic thickening, disintegration and digestion, thus reducing considerably both the water content and the biodegradable solids;
  - reducing disposal problems only to primary sludge. To this purpose an integrated incineration process can be used thus minimizing the exhaust gas production to such low values (for a WWTP serving 500.000 PE 3.100 Nm^3/h for primary sludge comparing to 5.800 Nm^3/h for mixed sludge) that these type of plant can be considered like a pilot plant;
  - giving more flexibility to sludge management considering that disposal of sludge is not accomplished by a unique solution.
- Sludge incineration should be preferentially performed with an on-site plant. The use of external incineration or co-incineration plants is not convenient whether the sludge has to be previously dried. In fact, the methane requirement for on-site thermal drying (34.4 and 71.7 L/m^3 WW, for primary and mixed sludge respectively) if no other waste heat is available, would be scarcely compensated by the biogas production from digestion only with flow sheet with sludge triage. With the conventional flow sheet energy requirement for sludge drying is much higher than the available energy with biogas. This option is not environmental friendly also considering the quite high amount of total gaseous effluent produced in drying and incineration (23.000-46.300 Nm^3/h for primary and mixed sludge, respectively, for a plant serving 500.000 PE).

Acknowledgment

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