Valorization of Kitchen Waste through Biogas Production for Sustainable Municipal Solid Waste and Sludge Management

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OBJECTIVE

- **to present an energy efficient municipal wastewater treatment involving anaerobic co-digestion of primary sludge (PS) & organic fraction of municipal solid waste (OFMSW) by the integration of kitchen waste (KW) for better valorization of these organic-rich residuals.**

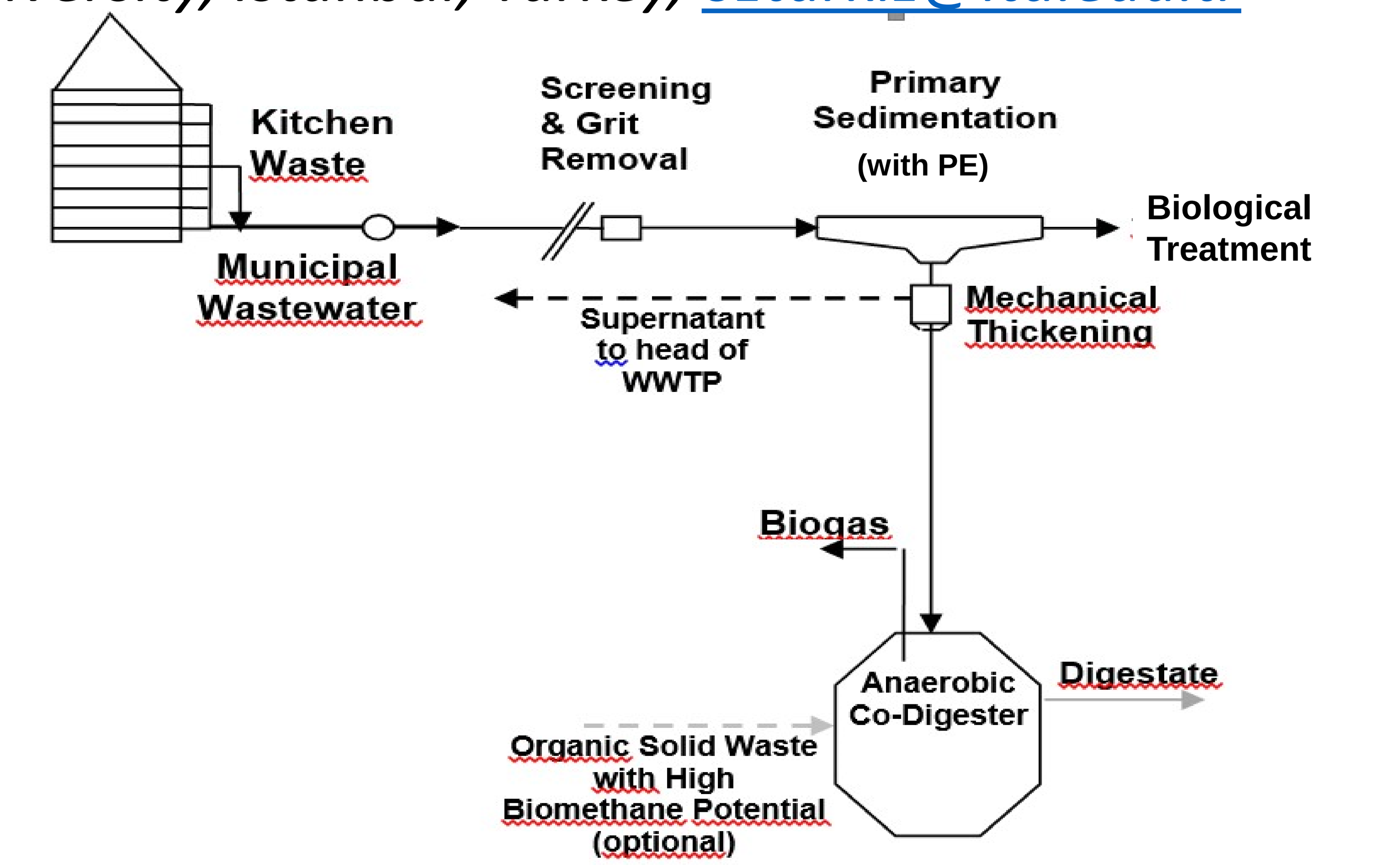
INTRODUCTION

- In order to mitigate the consumption of large amounts of energy & resources ⇒ great importance to find sustainable ways for an effective management of different types of residuals arising from residential areas such as KW & municipal solid waste (MSW) along with PS produced at wastewater treatment plants (WWTPs).
- KW ⇒ mostly organic waste (i.e., consists of fruits & vegetable wastes, waste oils or greases & cooking waste from food processing) with high putrefaction characteristics.
- MSW ⇒ several types of wastes (e.g., org. matter from food waste, paper & packaging wastes, yard waste, plastics, metals, textiles, and other miscellaneous items) continuously produced in high quantities.
- MSW ⇒ largest component of which is organic matter makes solid waste management a major environmental concern around the world.
- Usage of disposers ⇒ as a sustainable source reduction & waste minimization alternative by mixing the bulk of the OFMSW with domestic wastewater before reaching the sewage and ultimately WWTP.
- Separation of a considerable fraction of the organic-putrid food waste (FW) with substantial water content out of the entire MSW stream is possible.
- MSW moisture & leachate amount ⇒ reduced at a great extent.
- Primary Sludge (PS) ⇒ also comprised mainly of settled organic materials from raw sewage & food waste (dominated by proteins, carbohydrates & fats).
- Anaerobic digestion (AD) ⇒ most sustainable & feasible method for minimization & reuse of these residuals (efficient volume reduction, stabilization, biomethane provision from carbonaceous compounds & energy recovery from biogas).
- Sewage sludge occurring at municipal WWTPs ⇒ one of the most appropriate co-substrates for co-digestion with OFMSW.
- AD ⇒ allows stabilization of different large waste streams in the same reactor without any considerable additional investments [cost-effective & energy self-sufficient WWTPs].
- The penetration rate of KW (% of households with disposer installation over total households in a certain area) ⇒ directly affects annual CH_4 production.
- Although no significant impacts on water consumption, sewerage system & WWTPs at a small scale ⇒ additional capital & operational costs at large-scale WWTPs in case of long-term KW penetration.

CONCLUSION

- **Sustainable waste management especially in metropolitan cities like Istanbul ⇒ provided through disposer usage by diverting food waste from landfill.**
- **Daily methane gas production ⇒ ≥ 30,000 m³ by KW with a penetration rate of ≥ 90%.**
- **About one third less daily CH_4 & total energy generations ⇒ without KW integration.**
- **Substantial portion of energy consumption of WWTPs ⇒ covered by the improvement in biomethane recovery with the OFMSW feeding to co-digester with PS.**

Modified Municipal WWTP with KW & OFMSW



RESULTS & DISCUSSION

- Total energy (electricity & heat) generations from the produced biomethane ⇒ ~152,500 kWh (by a KW penetration rate of 40%).
- For energy consumption per unit of treated wastewater (~0.5 kWh/m³) ⇒ almost all daily energy need is covered.
- Potential total energy [megawatt; MW] ⇒ 6.36 with & 3.20 without KW.
- Increased KW penetration rates ⇒ lead to subsequent improvement in sludge & biogas depending on treatment processes at WWTPs.
- With a penetration rate of 90% ⇒ Daily total energy up to ~11 MW with an improved biogas (due to COD&TSS of influent increases by ≥ 50%).

Characteristics & Energy Potential of Modified Municipal WWTP

Description	Unit	Without KW	With KW[b]
Population	PE	1,000,000	
Wastewater production	L/PE.d	250	~258[a]
Influent flow-rate (Q_{inf})[a]	m³/d	300,000	
Chemical Oxygen Demand (COD)	mg/L	370	620
Total Suspended Solids (TSS)	mg/L	200	425
TSS removal in primary tank[c]	%	75	
COD removal in primary tank[c]	%	50	
Solids load (TS% of thickened PS)	kg/d	95400 (TS%=6)	
Biogas Production & Energy Equivalence			
Total biogas flow-rate (Q_{gas})	m³/d	16395	32600
Methane flow-rate (Q_{CH4})[d]	m³/d	9590	19100
Electricity energy ($N_{electric}$)[e]	kW/d	1400	2780
Heat energy (N_{heat})[e]	kW/d	1800	3575
Total energy (N_{total})[f]	kW/d	3200	6355

[a]By integrating disposers, daily water consumption (250 L/PE.d) increased by ~3%, including infiltration; [b]Daily per capita MSW generation is 1.5 kg, FW portion of MSW is 50%, TS content of FW is 28%, ground part of FW is 80%, penetration rate is 40%; [c]With polyelectrolyte; [d]CH_4 content of total biogas is 65%, safety factor is 90%; [e]1 m³ CH_4 yields about 10 kWh, $N_{electric}=Q_{CH4}x10x0.35$, $N_{heat}=Q_{CH4}x10x0.45$; [f]$N_{total}=N_{electric}+N_{heat}$.

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