3rd INTERNATIONAL CONFERENCE
on Sustainable Solid Waste Management

TINOS 2015

Assessment of Household Food Waste as a potential source for energy generation

K. Valta [(1)], M. Alexandropoulou [(1,2)], G. Antonopoulou [(2)], V. Drosou (1), V. Panaretou [(1)], J. Novakovitc [(1)], M. Loizidou [(1)], G. Lyberatos [(1)]

1. School of Chemical Engineering, National Technical University of Athens, 9 Iroon Polytechniou Str., Zographou Campus, GR-15773 Athens, Greece

2. Institute of Chemical Engineering Sciences (ICEHT/FORTH) , P.O. BOX 1414, 26504, Patras, Greece

Tinos, 3 July 2015

Objectives of the study

The objective of the present research was twofold:

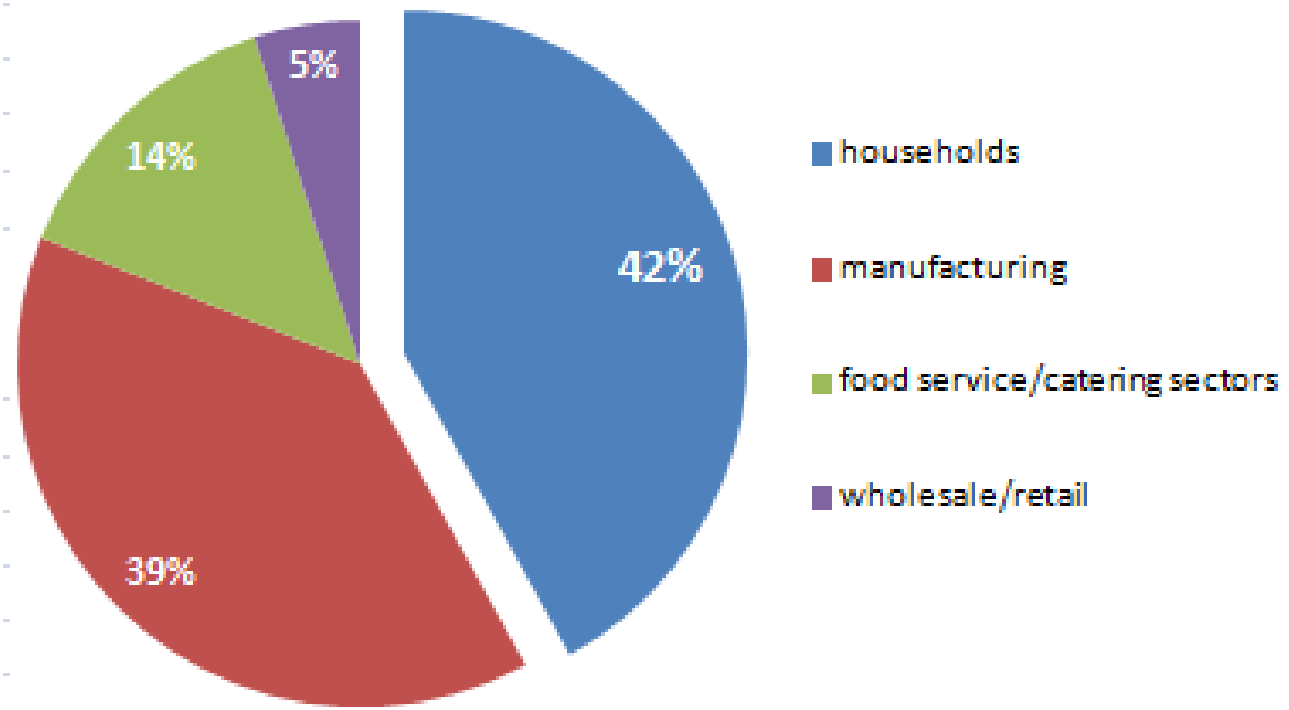
- To investigate the qualitative, quantitative and physicochemical characteristics of HFW produced in Greece
- To assess the potential of HFW for biogas production.

The language of food waste…

- There is no common definition of food waste….
- WRAP: defines **food waste** as all food and drink discarded throughout the entire food chain.
- **Food waste** is a part of **Bio-waste,** which includes the biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants *(Directive 2008/98/EC).*
- **Food waste** is a part of **Biodegradable waste** which includes any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard *(Directive 1999/31/EC).*

Quantities..

- Based on European Commission, 76 kg per capita per year i.e. **208 g/c/d** are produced.
- In total 40 Mt for the EU-27.



- As it can be observed Household Food Waste (HFW) constitutes the highest percentage (42%).

Methodology

Kitchen-waste-diary

5 two-member families:H1, H2, H3, H4 and H5 of Attica Region

28 consecutive days during winter

Preparation of HFW samples

(4 weekly samples for each household)

20 HFW Laboratory samples were prepared

NTUA

Laboratory Analysis

TS%, VS%, pH, conductivity, TC, TOC, TN, TKN, NH4, Metals (Cu, Mn, Ni, Cd, Pb, Cr, Zn) and minerals (K, Na, Ca Mg)

ICE – HT FORTH

BMP tests

Assessment of HFW

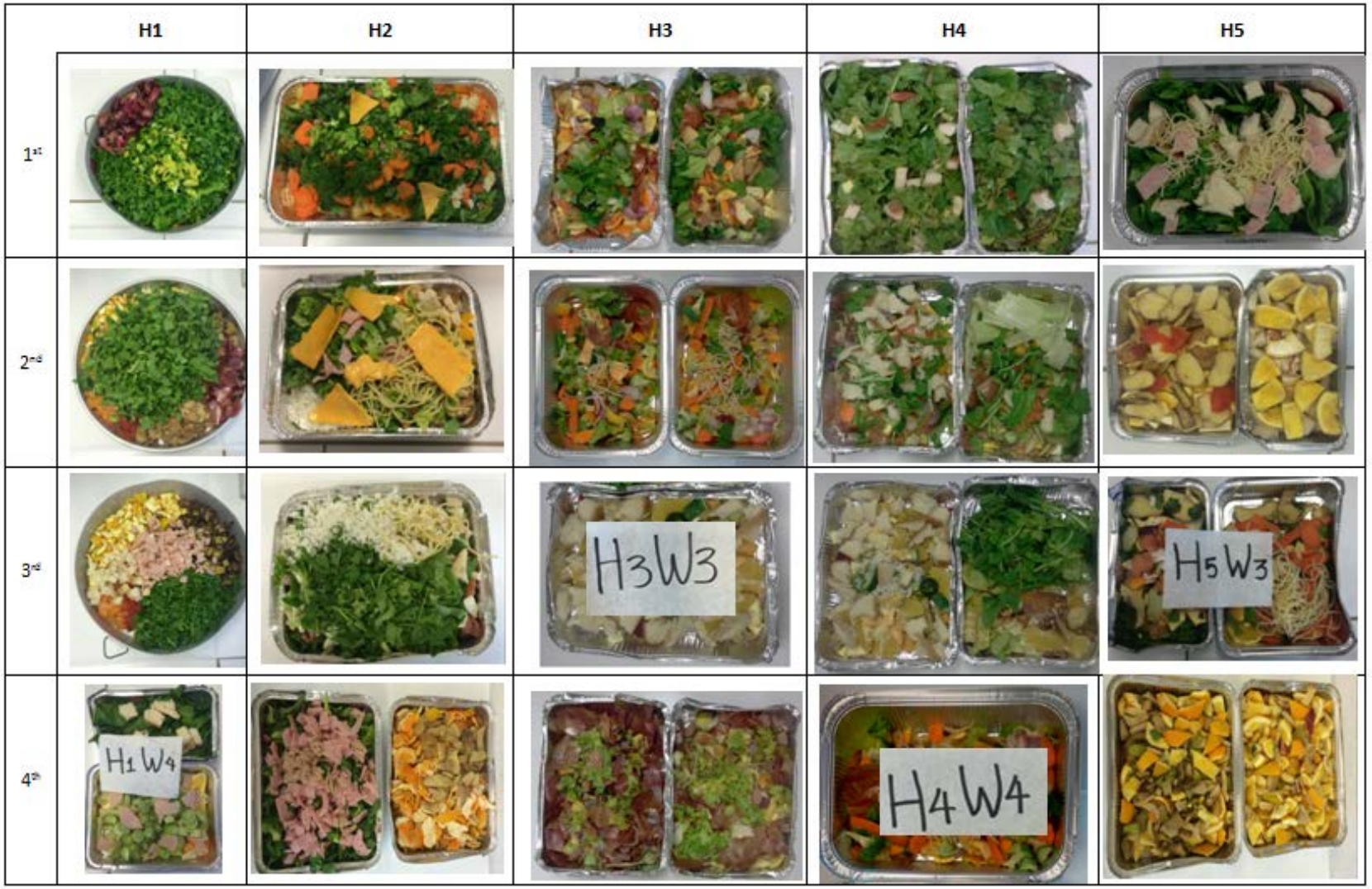
Household diary keeping

ΗΜΕΡΑ: ..... / ΕΒΔΟΜΑΔΑ:..... / ΗΜΕΡΟΜΗΝΙΑ: .....

ΤΥΠΟΣ	ΦΛΟΥΔΙΑ ή ΞΕΦΛΟΥΔΙΣΜΑΤΑ ΠΟΥ ΔΕΝ ΤΡΩΓΟΝΤΑΙ	ΠΕΡΙΣΣΕΥΜΑΤΑ ΑΠΟ ΜΑΓΕΙΡΕΥΜΕΝΟ ΦΑΓΗΤΟ ΣΑΠΙΣΜΕΝΑ ή ΠΟΥ ΕΧΟΥΝ ΛΗΞΕΙ
ΣΥΝΟΛΟ:		

Drinks and other special waste including tea bags, espresso capsules, yogurts and blood residues.

Preparation of HFW samples



Laboratory Analysis - NTUA

TS%: *Carbolite AX30 Furnance*

VS%: Bl Barnstead/ Thermolyne 1400 Furnace

pH: METTLER TOLEDO MPC227

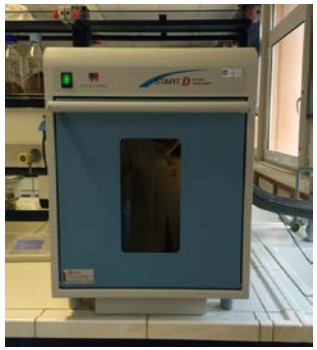
Conductivity: METTLER TOLEDO MPC227

TOC: Shimadzu TOC-VCSH - Solid Sample Module SSM 5000A

TN, TKN: Gerhard Kjeldatherm KB / KBL, Gerhard Vapodest 30s

Metals*: Cu, Mn, Ni, Cd, Pb, Cr, Zn*

Minerals *K, Na, Ca Mg* VARIAN AA240FS Fast Sequential



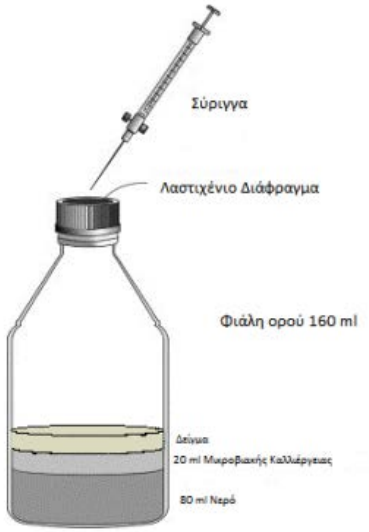
BMP Assays ICE – HT FORTH

- The assessment on methane generation was based on the results of batch mesophilic **Biochemical Methane Potential assays.**

- The BMP tests were carried out laboratory of Biochemical Engineering and Environmental Technology of the Institute of Chemical Engineering Sciences (ICE-HT/FORTH) in Patras

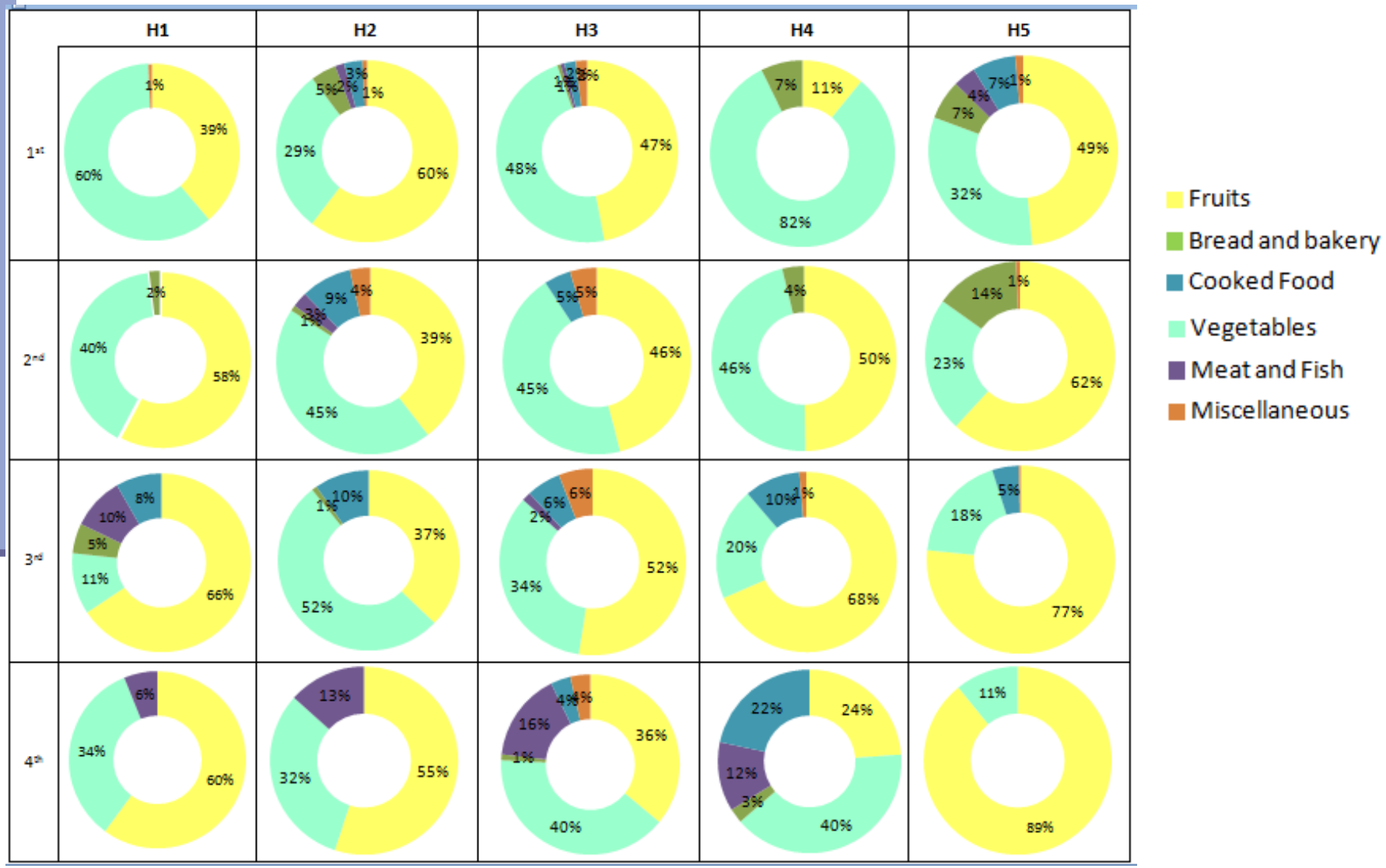
- BMP experiments for all substrates were carried out at the in duplicate at 35ºC according to *Owens J.M. and Chynoweth D.P.: Biochemical methane potential of municipal solid waste (M*
  Sci. Technol, 27, 1-14 (1993).

- The produced gas composition in methane was quantified with a gas chromatograph (SRI 8610c MG#1) equipped with a thermal conductivity detector and a packed column with helium as carrier gas.



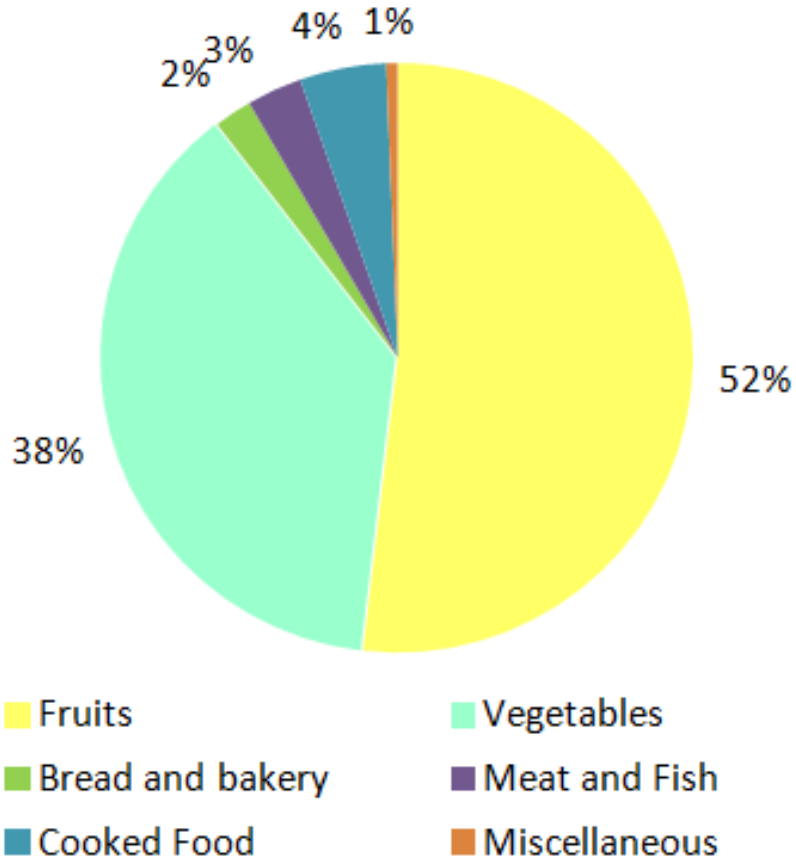
Results and Discussion (I)

Compositional analysis (w/w%) based on diary keeping



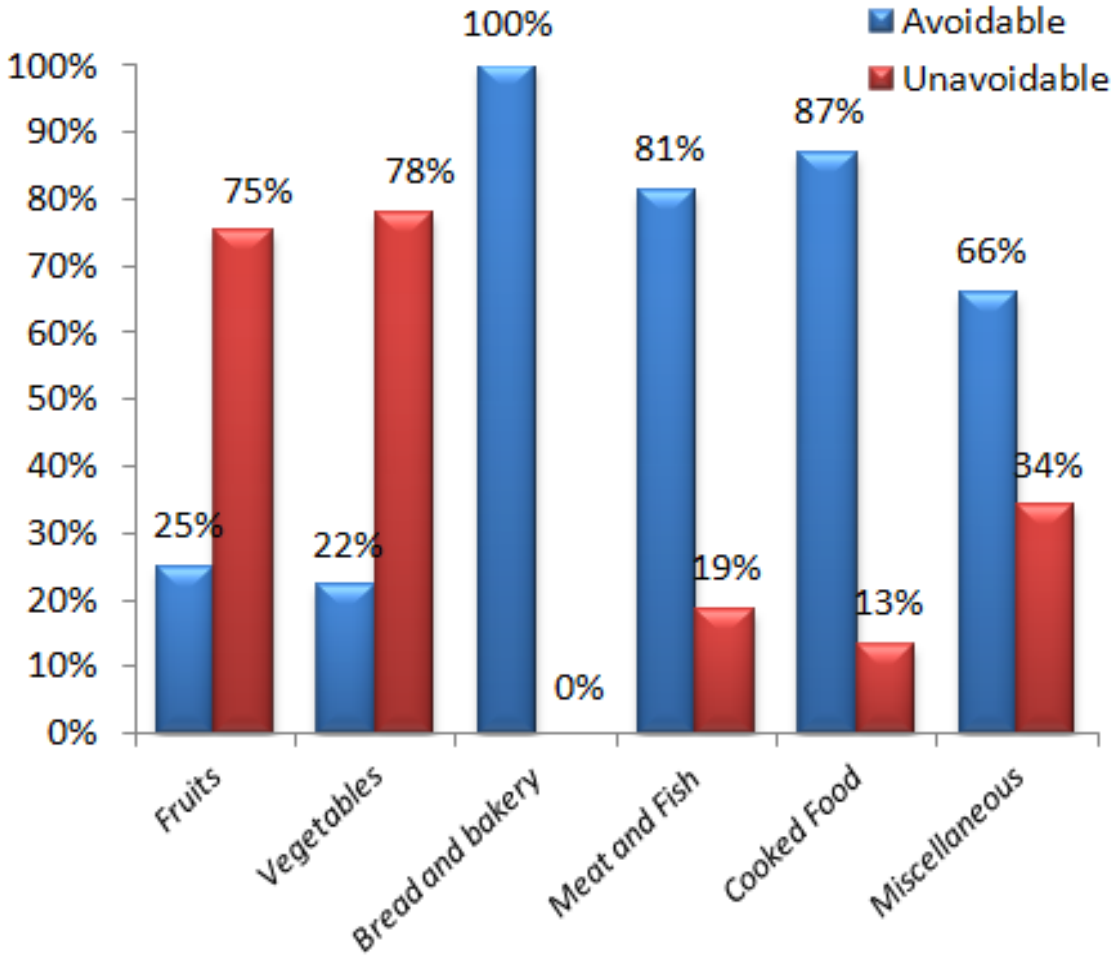
Results and Discussion (II)

Average composition of all samples (w/w%) based on diary keeping



Results and Discussion (III)

Avoidability between different food waste categories



In total 30% of the waste quantity recorded was avoidable and 70% unavoidable

Results and Discussion (IV)

Percentage of weight per household food waste category

Fruits	*51,9%*
Oranges	49,9%
Lemons	7,2%
Mandarins	17,3%
Apples	9,3%
Bananas	13,4%
Kiwis	0,5%
Strawberries	1,1%
Pears	1,2%

Vegetables	*37,7%*
Potatoes	14,6%
Lettuce	13,9%
Onions	12,8%
Cucumbers	9,9%
Broccoli	7,5%
Carrots	7,6%
Leafy salad	3,5%
Leeks	5,8%
Spinach	5,6%
Cabbages	2,7%
Rocket Salad	4,8%
Parsley	2,8%
Peppers	3,1%
Tomatoes	2,2%
Beans	2,3%
Mushrooms	0,5%
Dill	0,4%

Bread & bakery	*2,1%*
Bread	100%

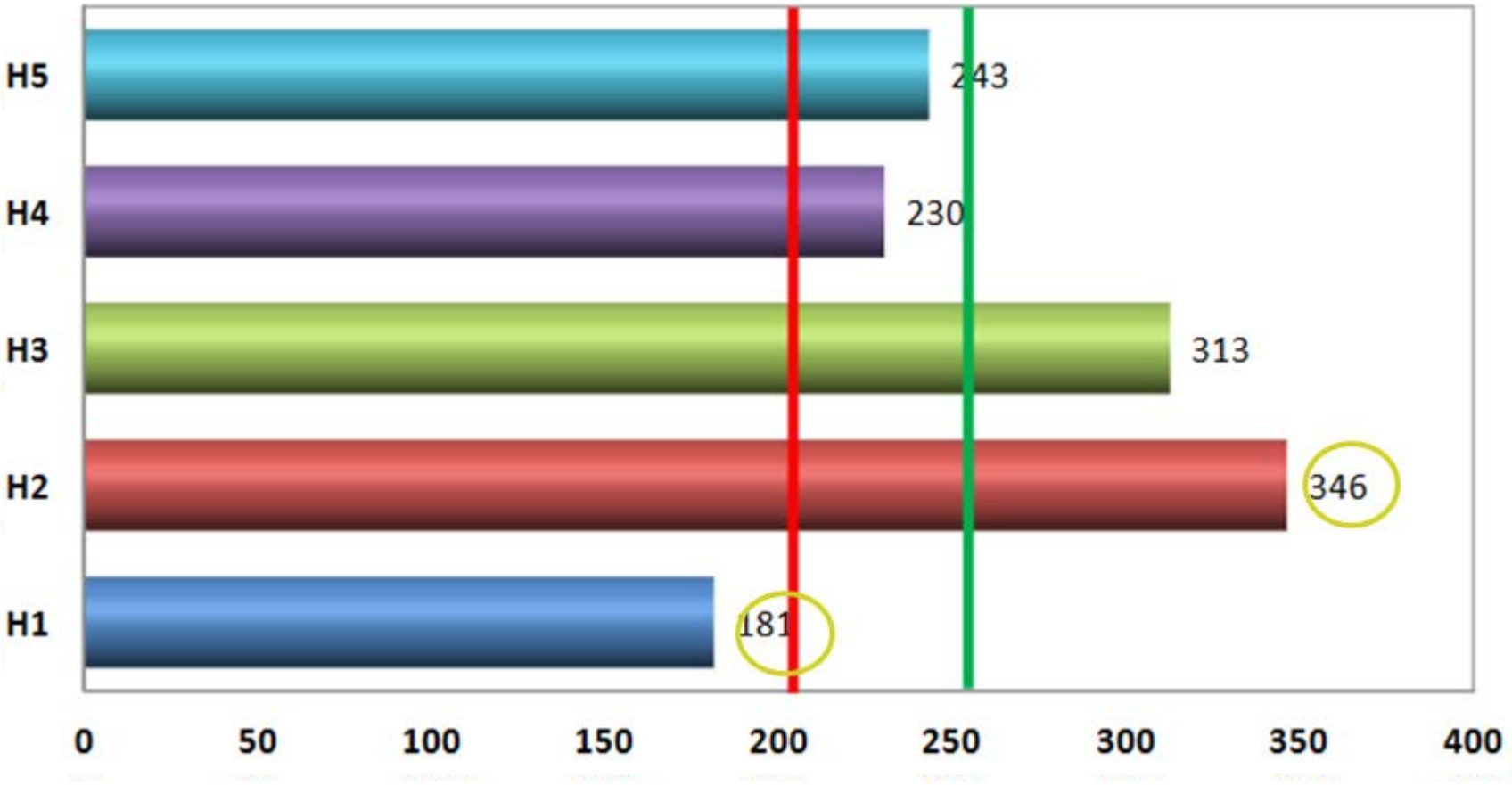
Meat & Fish	*3,0%*
Deli meats	46,5%
Chicken	24,6%
Fish	18,7%
Meat	1,8%
Sausages	8,4%

Cooked food	*4,7%*
Rice	29,8%
Spaghetti	33,9%
Mashed potatoes	15,5%
Fresh Beans	6,1%
Souvlaki pita	5,2%
Mixed Salad	6,4%
Lentils	3,1%

Miscellaneous	*0,6%*
Olive	384
Cheese	71
Eggs	12

Results and Discussion (V)

Daily per capita HFW production g/c/d

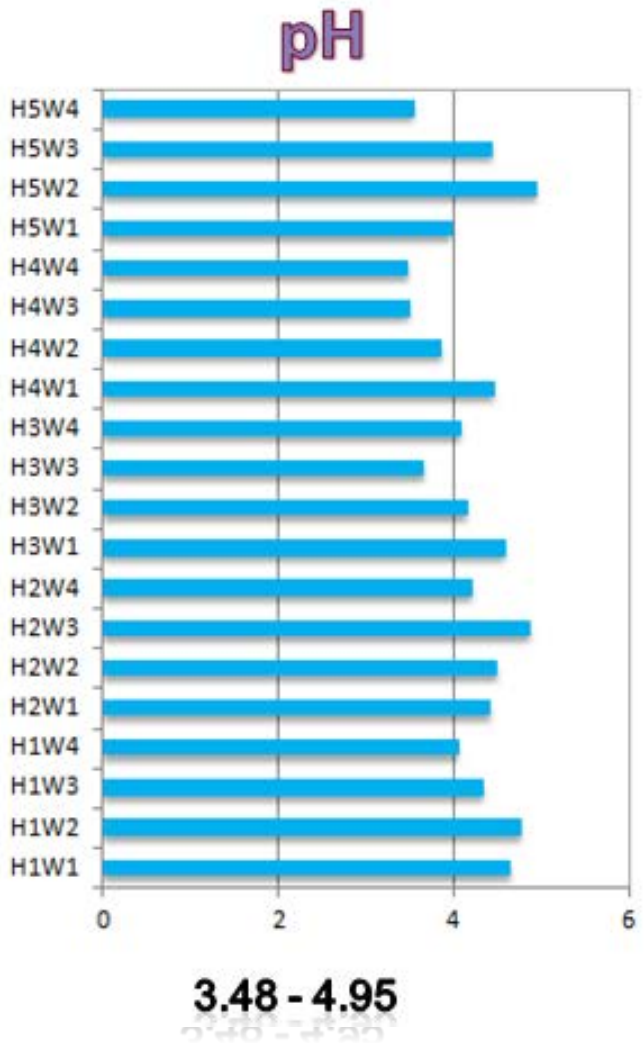


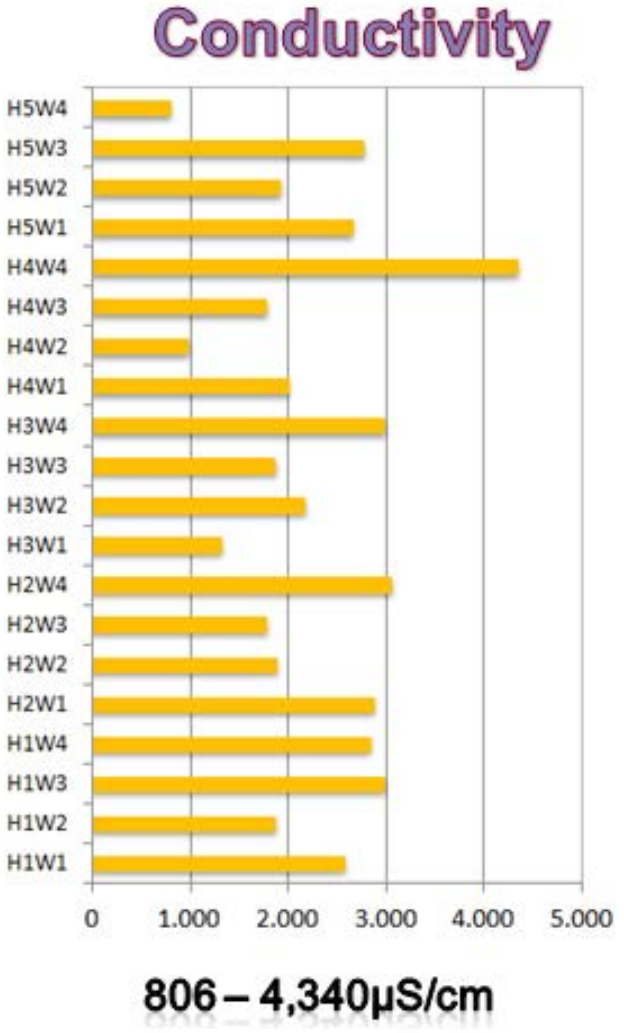
EU-27 GR

208g 263g

g/c/d

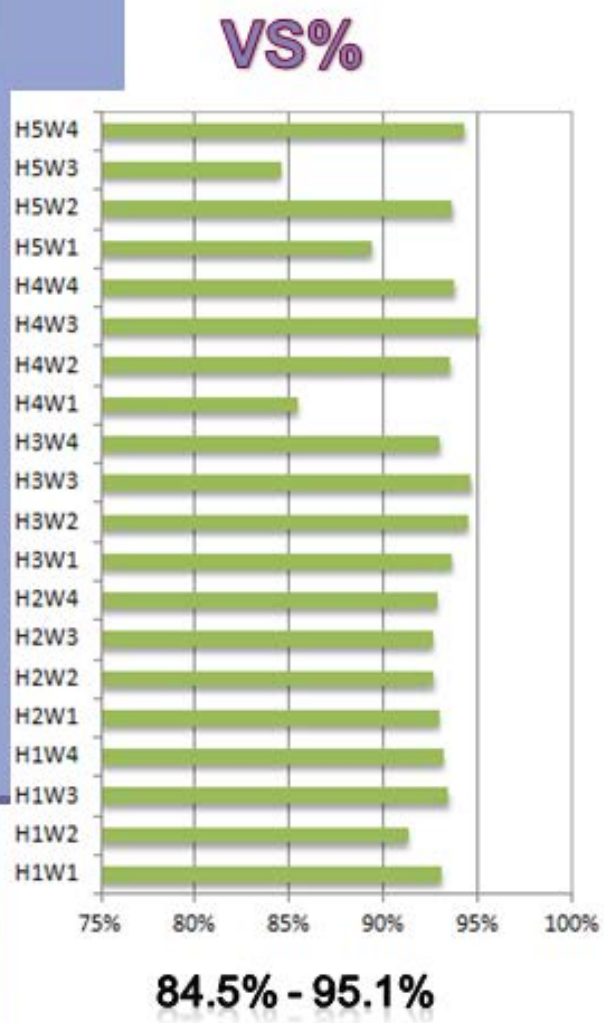
Results and Discussion (VI)

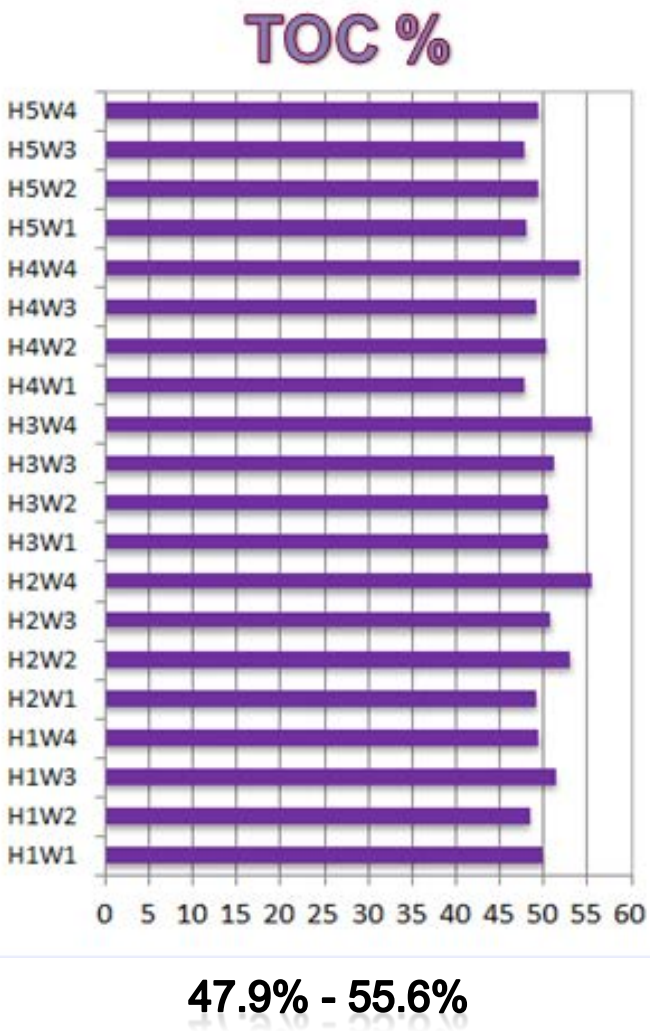


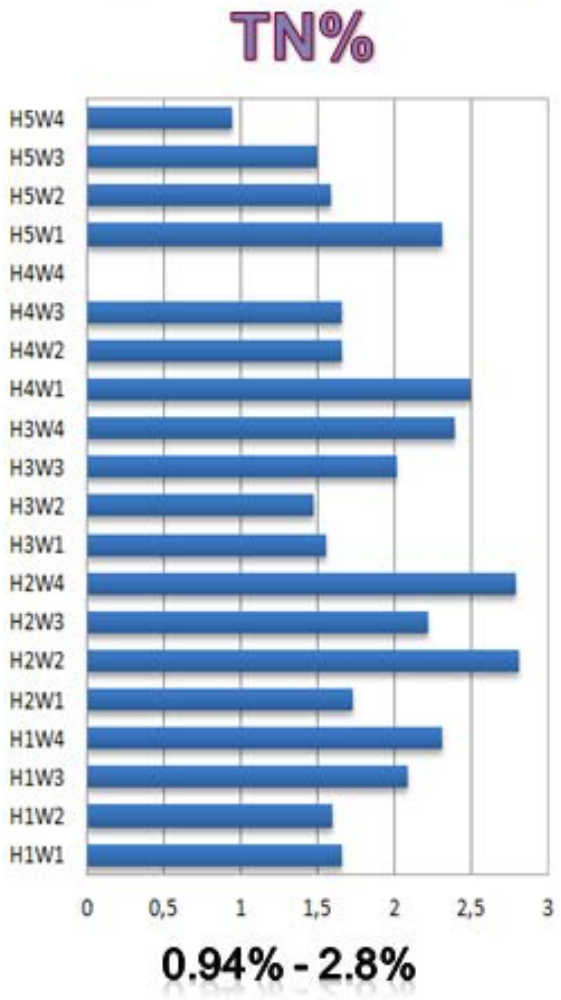


(1) The results are calculated in dry matter basis.

Results and Discussion (VII)







(1) The results are calculated in dry matter basis.

Results and Discussion (VIII)

Metals and minerals

	Cu mg/kg	Mn mg/kg	Zn mg/kg	K mg/kg	Na mg/kg	Ca mg/kg	Mg mg/kg
H1W1	1.72 ±1.23	16.90±2.66	22.61±7.14	19,476 ±2,016	1,988±349	8,978 ±1,188	2,818±913
H1W2	1.42±0.58	18.15±1.72	14.76±1.44	20,907 ±1,783	3,776 ±289	7,298 ±2,420	2,409±496
H1W3	0.53±0.93	8.48±3.22	20.51±3.34	11,573 ±3,107	3,695±898	2,859 ±507	807±190
H1W4	3.55±0.98	12.12±0.02	22.65±3.76	11,994 ±847	4,818±41	3,441 ±445	1,668±119
H2W1	0.55±0.16	19.73±0.12	12.11±10.50	8,775 ±284	6,556±225	4,623 ±260	1,707 ±43
H2W2	1.25±0.18	14.50±0.37	26.20±8.65	13,298 ±1,768	3,692±258	3,930 ±258	1,214 ±61
H2W3	3.60±0.27	17.94±1.03	17.29±0.96	14,349 ±914	2,452±75	6,820 ±250	1,431 ±71
H2W4	0.06±0.07	6.85±0.34	12.48±11.23	7,435 ±592	7,288±640	4,043 ±244	866 ±58
H3W1	*0.00*	9.72±0.56	16.80±2.44	12,105 ±879	1,413±79	4,793 ±250	1,179 ±59
H3W2	*0.00*	7.55±0.99	19.80±2.01	11,676 ±539	961±36	4,592 ±134	926 ±38
H3W3	*0.00*	6.92±0.37	14.12±12.28	11,409 ±3,345	835±265	4,844±1,463	851±249
H3W4	*0.00*	13.12±2.60	18.01±2.26	8,476 ±1,615	6,121±1,032	4,229 ±643	961±178
H4W1	14.34±1.65	22.02±1.43	83.34±52.99	14,762 ±1,047	4,141±162	4,173 ±231	1,709±114
H4W2	3.38±0.46	14.24±0.66	11.56±11.01	11,023 ±923	2,025±490	6,167±1,632	1,404±438
H4W3	0.57±0.59	8.06±0.23	14.68±0.64	9,491 ±406	2,024±94	3,501 ±168	763 ±63
H4W4	0.06±0.11	9.40±1.63	48.98±8.86	14,578 ±2,581	4,798±212	3,896 ±3,022	1,248 ±359
H5W1	0.09±0.12	12.03±0.40	9.09±7.89	12,834 ±526	6,111±1,135	20,011 ±2,575	2,914 ±995
H5W2	*0.00*	6.63±1.53	8.16±1.68	5,042 ±903	4,335±654	17,066 ±3,988	1,734 ±280
H5W3	3.08±5.33	21.35±4.24	29.12±11.86	15,882 ±453	2,234±860	36,997 ±4,716	2,159 ±864
H5W4	*0.00*	2.58±0.49	6.86±5.94	7,144 ±347	2,136 ±501	12,259 ±1,240	2,358 ±566

(1) The results are calculated in dry matter basis.

Results and Discussion (IX)

	L CH_4/kg TS	L CH_4/kg VS
H1W1	362±7.9	389±8.6
H1W2	367±25.5	402±27.9
H1W3	413±0.5	442±0.5
H1W4	444±10.1	490±10.8
H2W1	459±59.1	493±63.6
H2W2	445±46.8	480±50.5
H2W3	287±10.6	308±11.4
H2W4	519±60.8	559±64.3
H3W1	265±12.1	283±12.8
H3W2	449±2.1	475±2.5
H3W3	441±2.5	466±2.7
H3W4	459±1.7	494±1.8
H4W1	366±1.4	429±1.5
H4W2	304±64.7	325±72.4
H4W3	368±19.7	386±21.0
H4W4	442±11.7	471±13.9
H5W1	408±4.3	456±4.6
H5W2	433±8.0	460±8.6
H5W3	334±25.5	395±27.9
H5W4	386±0.5	410±0.5

BMP assays

265 - 519 L CH_4/Kg TS

283 – 559 L CH_4/Kg VS

Conclusions

- ‘Fruit’ and ‘Vegetable’ waste constitute the main waste categories of HFW recorded, accounting for almost 90%.
- In total 30% of the HFW could have been prevented.
- 30% of ‘Fruit’ and ‘Vegetable’ waste could have been avoided.
- Although variations exist, the average daily per year production of HFW was slightly higher (96 kg) to the one estimated for the EU-27 (76kg).
- HFW is characterized as having acidic pH values, high VS content and high TOC content.
- Based on the conducted BMP tests, source separated HFW are great substrates for high methane yields.

Thank you for your attention

katerinavalta@gmail.com

Unit of Environmental Science and Technology (UEST),
School of Chemical Engineering,
National Technical University of Athens (NTUA)

Tel: +30 210 7722334
Fax: +30 210 7723285