# Seaweed as a resource for anaerobic digestion

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## 1. Introduction

Extensive growth of algae contributes to disruptive changes to the water ecosystems. This is mainly caused by redundant nutrients that are washed off the land and end up in waters. Tackling eutrophication by recovery of nutrients can be a solution to the problem. Cast marine biomass can be a resource for renewable energy technologies like anaerobic digestion. Such approach can contribute to the transition to a circular bio-economy and to preserving recreational value of the area.

## 2. Methodology

The total solids and volatile solids values were determined using gravimetric method. An elemental analysis was performed with a ThermoScientific Flash 2000 analyser. The biogas potential was determined using OxiTop reactors with a volume equipped with pressure transmitters. The reactors were incubated at 37°C and stirred with a rotational speed of about 180 $min^{-1}$. The pressure was recorded every 24 hours with the OxiTop® Control OC 110 controller. When the pressure reached the upper limit value of the pressure transducer, the gas sample was collected for further gas composition analysis. At Gdańsk University of Technology measurements of heavy metals in biomass were provided using the inductively coupled plasma mass spectrometry (ICP-MS) on PerkinElmer NexION 300D apparatus.

## 3. Results

The amount of biomass found in the different regions of Baltic Sea basin differ significantly depending on the winds and sea currents. The seaweed ends up on the coastal areas where it accumulates, dries up and decomposes producing bad smell and residues that decrease the recreational value of the area. Theoretical annual amounts of seaweed in South Baltic countries (Lithuania, Poland, Germany, Denmark and Sweden) are estimated at over 1.8 million tonnes.

*Table 1. Biomass characteristics*

| Biomass | TS [%] | VS [%] | C [%] | N [%] | C/N |
|---|---|---|---|---|---|
| *Enteromorpha compressa* | 8.86 | 83.83 | 24.30 | 2.32 | 10.47 |
| *Enteromorpha plumosa* | 7.19 | 79.71 | 19.48 | 1.48 | 13.16 |
| *Potamogeton pectinatus* | 13.07 | 61.39 | 15.27 | 1.74 | 8.78 |
| *Zostera marina* | 12.56 | 79.63 | 24.28 | 1.62 | 14.99 |
| *Mixed biomass* | 17.23 | 63.87 | 13.74 | 1.37 | 10.03 |

Pure species of maritime biomass were obtained from a natural water reservoir and from the shore of the Puck Bay area in Poland. Harvesting of marine plants for methane fermentation tests was done by hand at the seashore and at shallow waters during the summer. The mixed cast seaweed samples collected from Polish beaches consisted of marine plants and macroalgae. In addition, it contained small amounts of land plants, in particular tree leaves, branches, as well as feathers and small invertebrates.

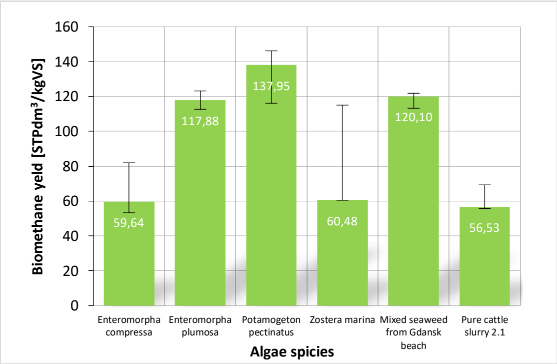


*Figure 1. Biomethane potential of marine biomass and cattle slurry in 1:3 ratio*

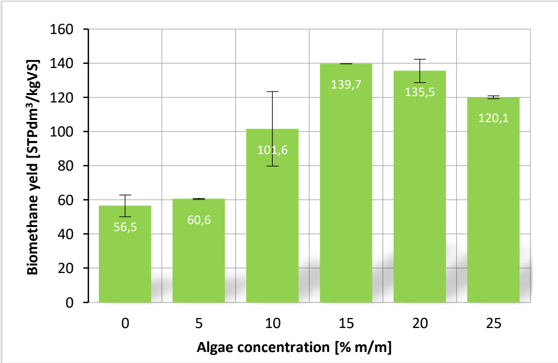


*Figure 2. Biomethane potential of marine biomass and cattle slurry*

Addition of the seaweed resulted in bio-methane yield increase compared to pure cattle slurry. The lowest increase was observed with Enteromorpha compressa (27.51%) and the highest one with Potamogeton pectinatus (151.91%).

Also, the concentration of seaweed was found to have an impact on the process efficiency. An increase of bio-methane yield was observed when the algae concentration in the feedstock mixture was above 5%. Below 5% in the mixture, the yield was similar to pure cattle slurry, however the addition of 25% resulted in a sudden drop in bio-methane yield when compared to 20% (144.55 to 211.05 STP $dm^3$/kg VS respectively).

The main limiting factor of further digestate use an organic fertiliser is the heavy metals content which at some seasons can exceed the thresholds. Table 2 presents the heavy metal contents in species found in Poland, which all are far below admissible limits.

## 4. Conclusions

Seaweed seems to have a great potential as a feedstock in AD as they do not compete with terrestrial plants for agricultural land, but potential heavy metals content rises concerns in further digestate utilization.

Taking into account the C:N ratio, seaweed found on the polish coast had lower ratio than the optimal range for anaerobic digestion (20:1 - 30:1 C:N). Therefore, they should be processed in co-fermentation with other resources.

## 5. Acknowledgements

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*Table 2. Heavy metals content in marine biomass*

| | | Cattle slurry | Enteromorpha compressa | Enteromorpha plumosa | Zostera Marina | Biomass mix |
|---|---|---|---|---|---|---|
| **Heavy metals [mg/kg TS]** | Cu | 6.64±0.04 | 0.5±0.01 | 0.47±0.01 | 1.33±0.01 | 12.8±0.03 |
| | Fe | 87.3±0.44 | 117±1.13 | 211±1.27 | 396±0.44 | 2830±6.23 |
| | Cr | 0.27±0.01 | 0.16±0.01 | 0.23±0.01 | 0.64±0.01 | 3.47±0.01 |
| | Ni | 0.68±0.01 | 0.17±0.01 | 0.2±0.01 | 0.65±0.01 | 4.3±0.01 |
| | Cd | 0.02±0.01 | 0.03±0.01 | 0.03±0.01 | 0.14±0.01 | 0.49±0.01 |
| | Hg | 0.01±0.01 | 0.31±0.01 | 0.13±0.01 | 0.34±0.01 | 1.39±0.01 |
| **$P_{Total}$ [mg/kg TS]** | | 1070±5.35 | 745±7.16 | 248±1.49 | 734±0.81 | 881±1.94 |