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Nutrient content in macrophyta collected from southern Baltic Sea beaches in relation to eutrophication and biogas production

K. Bucholc [a], M. Szymczak-Żyła [a], L. Lubecki [a], A. Zamojska [b], P. Hapter [a], E. Tjernström [c], G. Kowalewska [a,*]

[a] Marine Pollution Laboratory, Institute of Oceanology, Polish Academy of Sciences, ul. Powstańców Warszawy 55, 81-712 Sopot, Poland
[b] University of Gdańsk, Department of Econometrics, ul. Armii Krajowej 101, 81-824 Sopot, Poland
[c] Environmental Department, Trelleborg Municipality, Algatan 13, 231 83 Trelleborg, Sweden

HIGHLIGHTS

- N and P in macrophyta depend primarily on their morphology and next on environment.
- Collecting macrophyta decreases the N/P ratio in the sea.
- Macrophyta biomass for biofuel needs addition of other carbon-rich biomass.
- Biogas production from macrophyta can decrease eutrophication only on a local scale.
- Biofuel production should be evaluated basing on economic efficiency and environment.

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ABSTRACT

One of the signs of eutrophication is the excessive growth of opportunistic macroalgae, a worldwide phenomenon also observed in the Baltic Sea. Mats of macroalgae may drift long distances and accumulate at the seashore, considerably decreasing the recreational value of beaches. The matter accumulating at the shore is treated usually as waste. However, it could be used, for example, as a resource for biogas production. The aim of this work was to verify the hypothesis that collecting of macrophyta accumulating on the beach and potential usage of this material for biogas production will decrease nutrient reserves in the sea to counteract eutrophication and the increase in greenhouse effects. Samples of macrophyta were collected in 2011 and 2012 and analysed for their C, N, and P contents, and degree of degradation (% Chl-*a* in the sum of chloropigments-*a*); the results were analysed statistically. The nutrient content was studied in macrophyta accumulating on the beach (Sopot, Gulf of Gdańsk, Poland) and for comparison, macrophyta collected from their habitats in less nutrient polluted area (off the Skåre coast, Trelleborg, Sweden). The nutrient content (N, P) in macrophyta depends primarily on their morphology and only secondarily on environmental nutrient pollution. Collecting the macrophyta biomass accumulating on beaches will not significantly change the eutrophication of the Baltic as a whole; any improvements in this respect are likely to be on a local scale only. Collecting macrophyta removes more nitrogen than phosphorous, so this would decrease the N/P ratio in seawater. This macrophyta biomass is a substantial reserve of renewable energy, which could be utilized with the appropriate technology for biomass collection/preservation and biofuel production as an additive to other carbon-rich biomasses. And the biofuel production should be evaluated not only from the standpoint of economic efficiency but also from the environmental point of view.

1. Introduction

Macrophyta are very important constituents of the marine environment. However, the excessive proliferation of opportunistic macroalgae is a growing environmental problem in many coastal zones worldwide (Bonsdorff et al., 1997; Burkholder et al., 2007; Cloern, 2001; Kennison et al., 2011; Lapointe and Bedford, 2011; Orive et al., 2002; Pihl et al., 1999). Changes in consumer populations and elevated nutrient loadings enlarge algal cover and biomass, and change the species composition (Valiela et al., 1997; Eriksson and Bergström, 2005; Ballesteros et al., 2007). For example, some fast-growing green algae such as *Cladophora* sp. may become dominant when the abundance of both macro- and meso-grazers decreases (Lotze et al., 1999; Mörk et al., 2009). Apart from biological and chemical (nutrients) factors, physical conditions – light, temperature and hydrodynamics – are also environmental factors affecting many aspects of macroalgal ecology (Carr et al., 1997; Sfriso et al., 1992; Cherbadgy et al., 2010; Sjöö et al., 2011).

* Corresponding author.

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A large biomass of macrophyta is a sign of eutrophication, one of the main problems of aquatic environments nowadays (Arévalo et al., 2007). The Baltic, being a semi-enclosed sea, is especially sensitive to eutrophication and in consequence, to the algal proliferation (HELCOM, 2009, 2013; Aleksandrov, 2010). These are principally opportunistic green (e.g. *Cladophora* sp.) and brown (e.g. *Pilayella* sp.) filamentous algae (Berglund et al., 2003; Lotze et al., 1999). Macrophyta mats are capable of floating great distances and accumulating at the water-line on beaches. Although this is a natural phenomenon (Biber, 2007; Lauringson and Kotta, 2006; Kersen and Martin, 2007), the problem lies in its scale and location. Macrophyta mats deposited on beaches in the middle of the tourist season are a serious problem. This foul-smelling, decomposing vegetation considerably diminishes the recreational value of beaches, not to mention the fact that bathing is not recommended when marine algae accumulate there. In Sopot, a resort on the coast of the Gulf of Gdańsk (southern Baltic), the beach situated near the town centre plays a very important role. Neither macroalgae nor seagrass grows near the beach. They are transported there by waves and currents, which depend mainly on wind speed and direction, whereas the growth of these macrophyta in the place of their origin depends on the nutrient input and hydrometeorological conditions prevailing there. The appearance of macrophyta on a beach (Supplement 1) is therefore neither a permanent nor a regular phenomenon, so the amount and composition of this biomass are difficult to forecast (Filipkowska et al., 2009). The Trelleborg beach is located close to the Danish Sounds and the North Sea, but even so, macrophyta accumulate along the 35 km long water-line in that popular recreational area. However, one can expect cleaner water there than in Sopot according to HELCOM, which states there 'moderate' eutrophication status and the 'bad' status in the Gulf of Gdańsk (HELCOM, 2010).

Among the different ideas put forward for counteracting eutrophication of the Baltic is the collection of the biomass accumulating on the shore and its utilization for biogas production (WAB, 2010; Filipkowska et al., 2008). In this case only the macrophyta biomass accumulated at the water-line would be collected; though even collection of limited amounts of growing red macroalgae for industrial purposes is practised in the Baltic without damage to the ecosystem (Kersen et al., 2009).

Removal of plant matter from the shore would not only lower nutrient loads in watercourses, for example, but also decrease the nutrient content in the sea. Nutrient content in marine macrophyta depends both on the morphological characteristics of particular species and the nutrient concentration in the environment (Pérez-Mayorga et al., 2011). The idea of biofuel production from the macroalgae has been considered since many years, but from technological and climate change point of view as high potential biomass (Gunaseelan, 1997; Pihl et al., 1999; Singh and Olsen, 2011), but still on the stage of search for economically efficient technological solutions (Cecchi et al., 1996; Aresta et al., 2005; Bastianoni et al., 2008). Moreover, algae have been used for removing nutrients from wastewaters or polluted water courses (Singhal and Rai, 2003; Marinho-Soriano et al., 2009; Mata et al., 2010), although these were mostly unicellular algae (Mulbry et al., 2010; Yen and Brune, 2007; Sialve et al., 2009; Park et al., 2011).

The aim of this work was to verify the hypothesis that collecting of macrophyta accumulating on the beach and potential usage of this material for biogas production will decrease nutrient reserves in the sea to counteract eutrophication and the increase in greenhouse effects. To achieve these the amounts and proportions of nutrient elements – N, P and C – in macrophyta on the Sopot and the Skåre/Trelleborg beaches (southern Baltic) were determined, to evaluate the effects that such biomass collection might have on the ecosystem and to calculate the C/N ratio, the basic indicator determining the value of biomass, e.g. for biogas production (EUBC&E, 2012). Macrophyta biomass accumulation on the beach has been estimated. Relation between nutrient content and degree of degradation of the biomass has been determined.

2. Materials and methods

2.1. Sampling sites and sample collection

The sample collection sites are shown in Fig. 1. The samples were collected on the Sopot beach (south-western part of the Gulf of Gdańsk) in 2011 and 2012, and off the Skåre beach near Trelleborg (southern Sweden, Scania coast) in 2012. The samples were collected during summer monitoring, to include the most abundant taxons for the southern Baltic and also samples collected during the highest macrophyta accumulation at the Sopot beach. In Trelleborg the samples of most abundant genus/species have been collected.

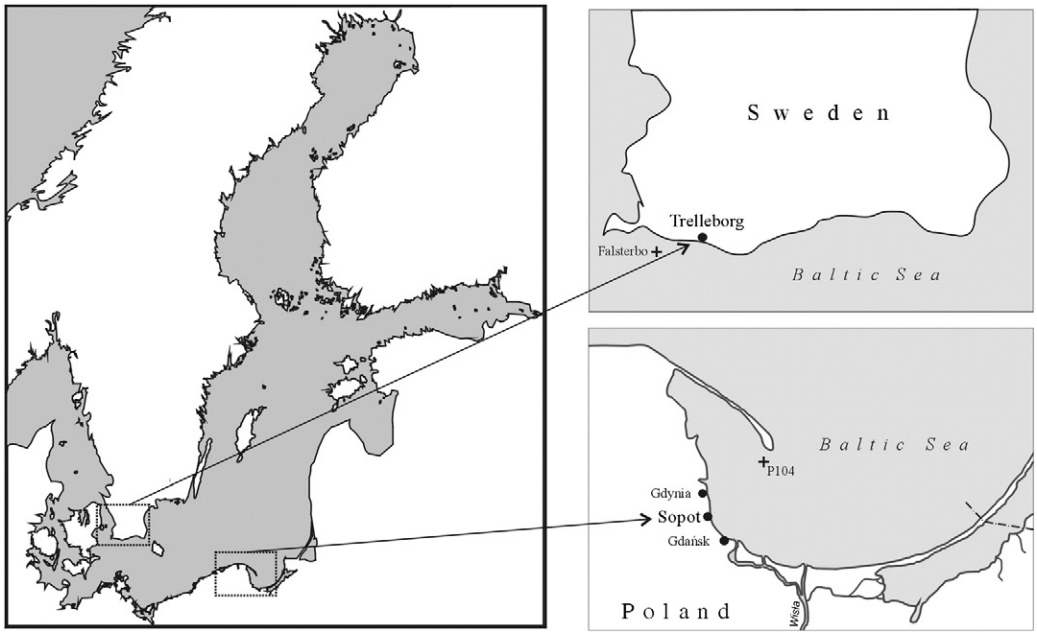

Fig. 1. Study areas.