Life cycle impact assessment in wastewater treatment process

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Wastewater treatment plant „Klaipedos vanduo“

Wastewater plant „Klaipedos vanduo“ while processing the wastewater, produces the sewage sludge in amounts reaching the average of 12 568 tons of dewatered sludge every year. Since the year of 2014 the sewage sludge started to be stockpiled at sludge storage sites of the wastewater plant. The steady amounts of the sewage sludge dry mass started to accumulate at sludge storage sites since 2016, reaching the yearly average quantities of 2370 tons of dry mass.

Wastewater treatment plant „Klaipedos vanduo“

Nevertheless, of the decrease of the processed wastewater since 1995 at „Klaipedos vanduo“ the stockpiled dewatered sludge amounts reached the 327 791 tons (60 066 tons of d.m.) at existing sludge storage sites.

By the date the existing sewage stockpiling sites are filled by 89.2%. Obviously, the additional installations for stockpiling produced sewage sludge at “Klaipedos vanduo“ would be costly and the treatment of produced sludge in the future should be considered.

Wastewater treatment plant „Klaipedos vanduo“

Filling of the sewage sludge sites at wastewater plant „Klaipedos vanduo“

PARAMETER / SITE	EXISTING SITE	OLD SITE	TOTAL
Capacity of sites (dewatered sludge)	140 000 tons	227 600 tons	367 600 tons
Filling (dewatered sludge)	100 191 tons	227 600 tons	327 791 tons
Filling (dry mass of sludge)	21 146.8 tons	38 919.6 tons	60 066.4 tons
Filling (in percent)	71.6 %	100 %	89.2 %

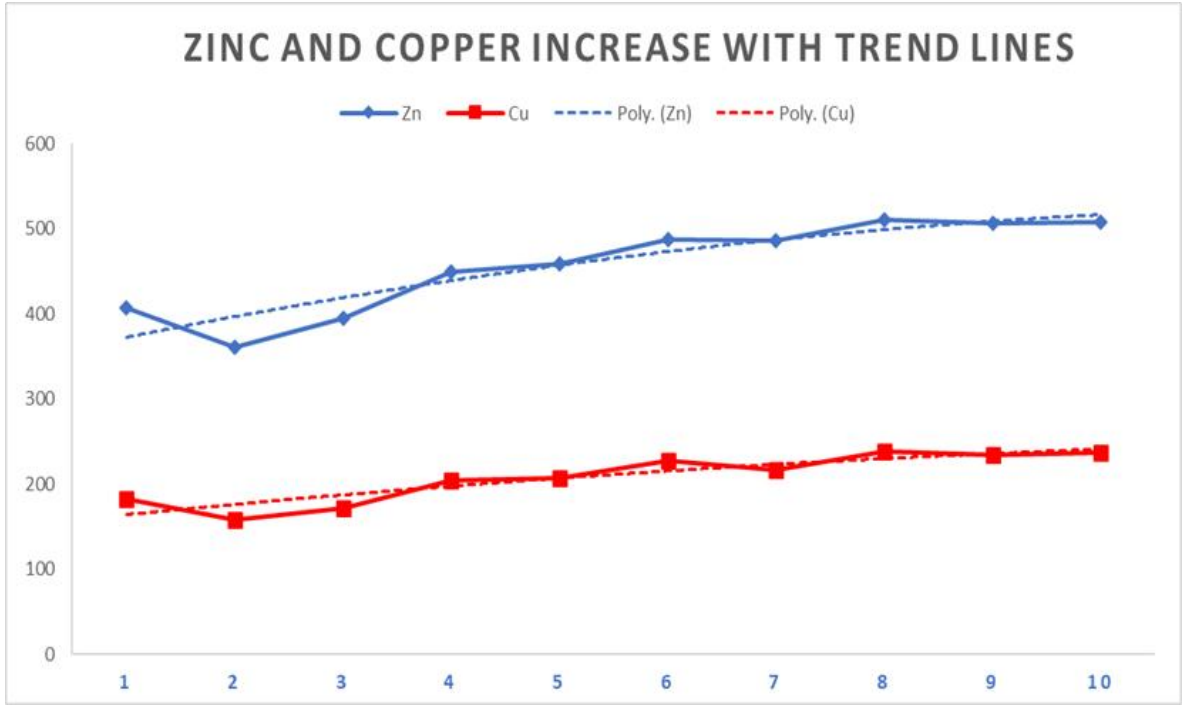
The high demand for management of the sewage sludge in alternative ways was identified. Two potential alternatives against the sewage sludge stockpiling at the existing sludge sites were proposed (The LCIA was completed for these two alternatives):

- *Incineration at “Akmenė Cementas“ plant;*
- *Composting of the sewage sludge at the existing sites and its use in agriculture at Klaipeda County.*

Research methods

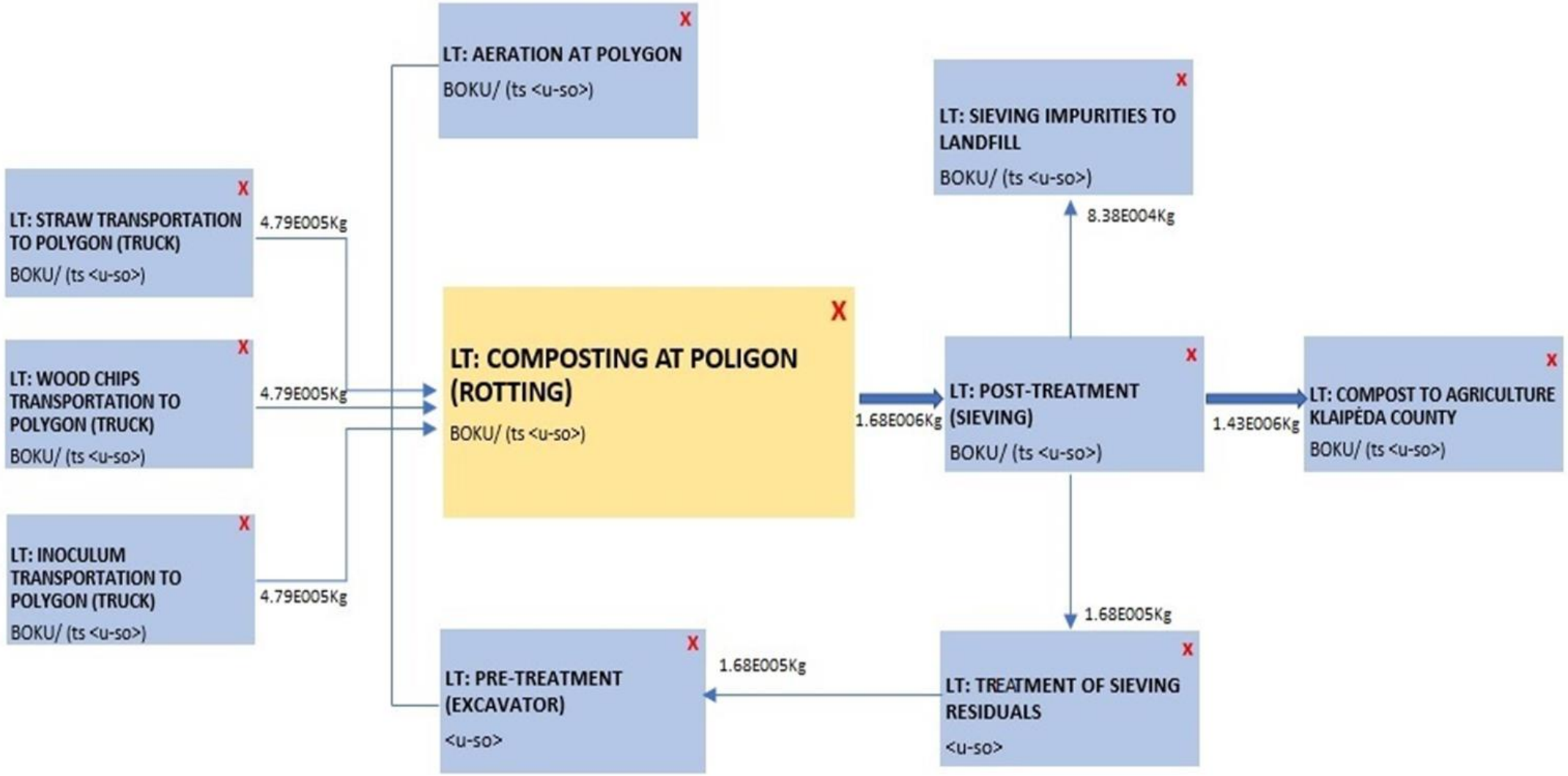
- The data reported by Sidełko et al., (2019) was used (averages of 140 days composting with 10 samplings in spring and autumn periods). The changes of the concentrations of the heavy metals during the process of the sewage sludge composting were analysed to apply the analogy for prediction of the change of concentrations of the heavy metals in the sewage sludge compost at wastewater plant “Klaipedos Vanduo”. To model the polynomial trend line fits the MS Excel® program was used. The PTF’s were derived fitting the 2nd order polynomial trend lines to the heavy metal concentrations data of the compost of the sewage sludge;
- The Life cycle impact of the sewage sludge composting was modelled using the Gabi ts® software. Following sludge composting method by Sidełko et al., (2019) the LCI was modeled for „Klaipedos vanduo” sludge sites. The flow parameters equal to 4:1:1:1 ratio (higher C/N ratio) was used for modeling (±40% parameter of the statistical standard deviation). The materials chosen - *sewage sludge : straw : wood chips : mature compost .* The inputs for analysis used – CH4, N_2O, NH3, NMVOC, CO_2, CO, VOC, HC, NO_X, PM, SO_2. Modeled outputs – Global warming potential, Acidification potential, Human health criteria Air, Smog Air.

Results of the study



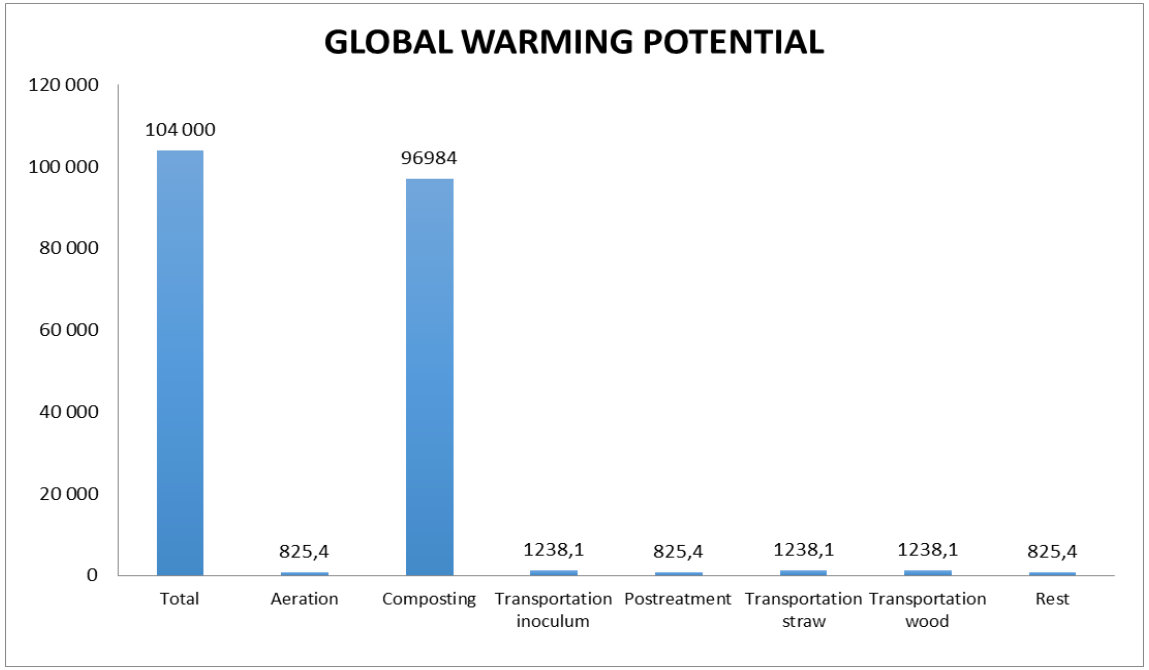
Zn and *Cu* concentration charts with resulting polynomial trend lines, during 140 days sludge composting period. *Y*-axis marks the units in mg/kg in dry mass, *X*-axis marks samplings.

- Data acquired by Sidełko et al., (2019), during their research with compost of sewage sludge compost found that sludge compost changes their properties (concentrations of heavy metals) in 140 days in the ways, that fall within the limits of Lithuanian sludge classification requirements, that allows to use the composted sludge in agriculture as a result. Two problematic concentrations of Zn and Cu after the 140 days composting stays above the limit of the sewage sludge class No II, that can be used in agriculture with restrictions;
- With the ratio of the sludge : woodchips+straw : mature compost (ratio 4:1:1) the C/N ratio increase reaches ~50%, increase in dry matter ~30%;
- Using the data by Sidełko et al., (2019), as well municipal sewage treatment plant monitoring data it was equated polynomial trend lines and potentially resulting concentration in the sewage sludge compost during its composting at „Klaipėdos Vanduo“ sludge stockpiling sites.

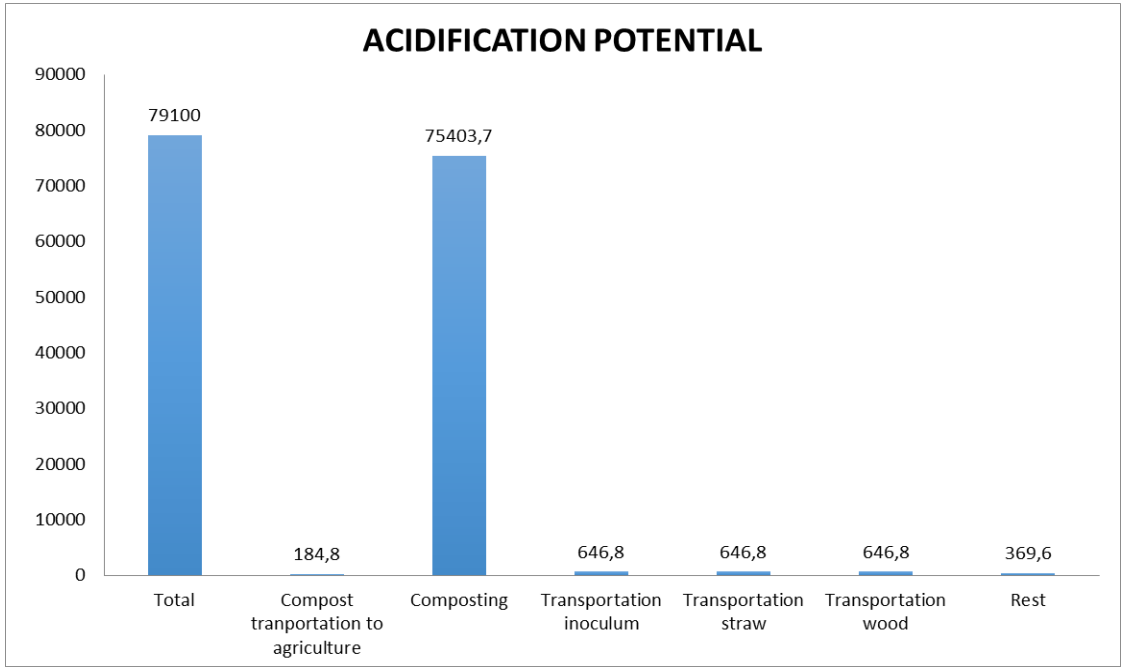


Modelled flows of the sewage sludge composting at wastewater plant „Klaipedos vanduo“ („X“ marks the valuable flows)

Results of the study

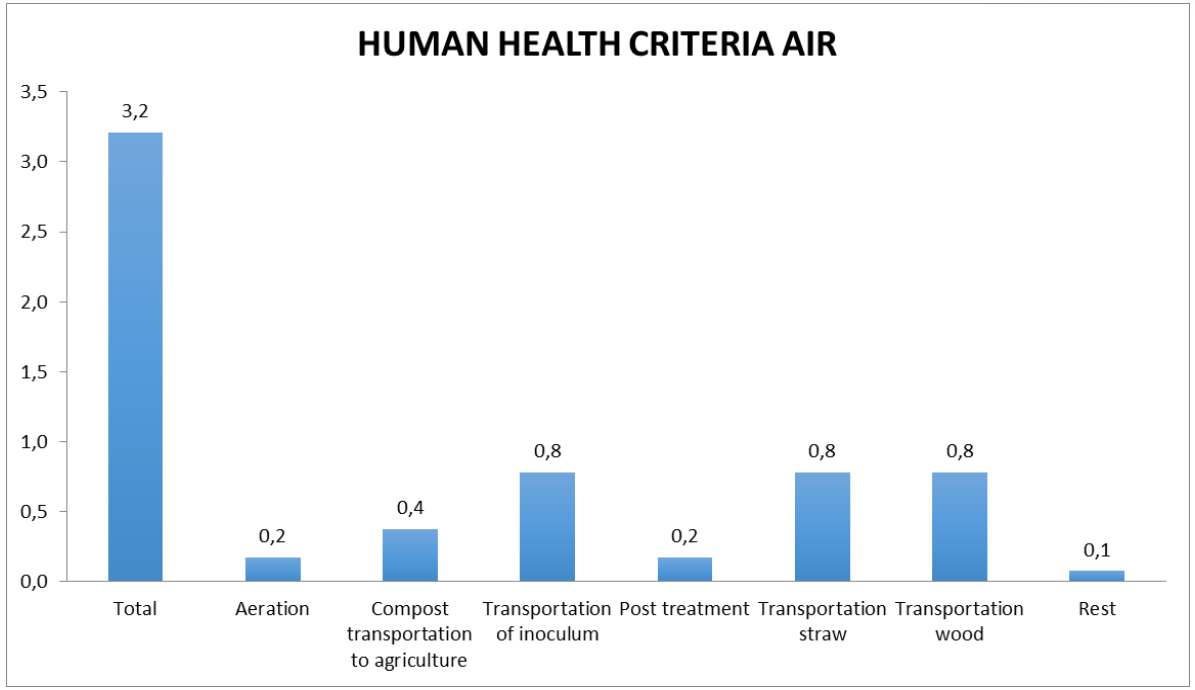


Modeled potential of the Global Warming of the composting. Y-axis marks the units in kg CO_2 Equivalent.

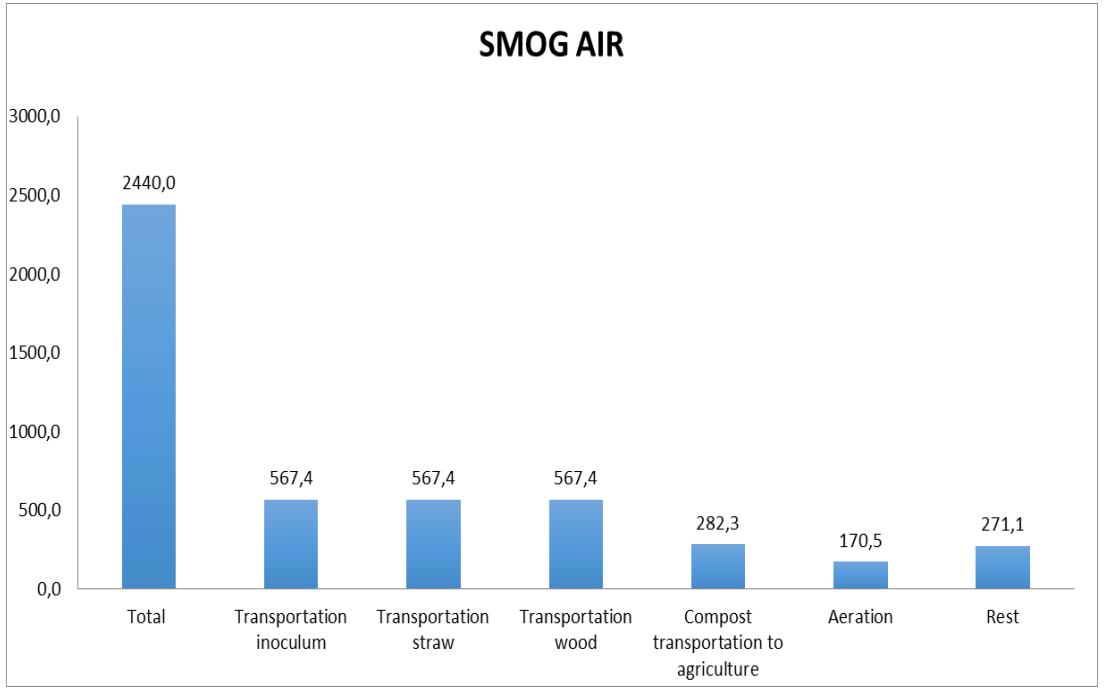


Modeled potential of the Acidification of the composting. Y-axis marks units in moles H+ Equivalent.

Results of the study

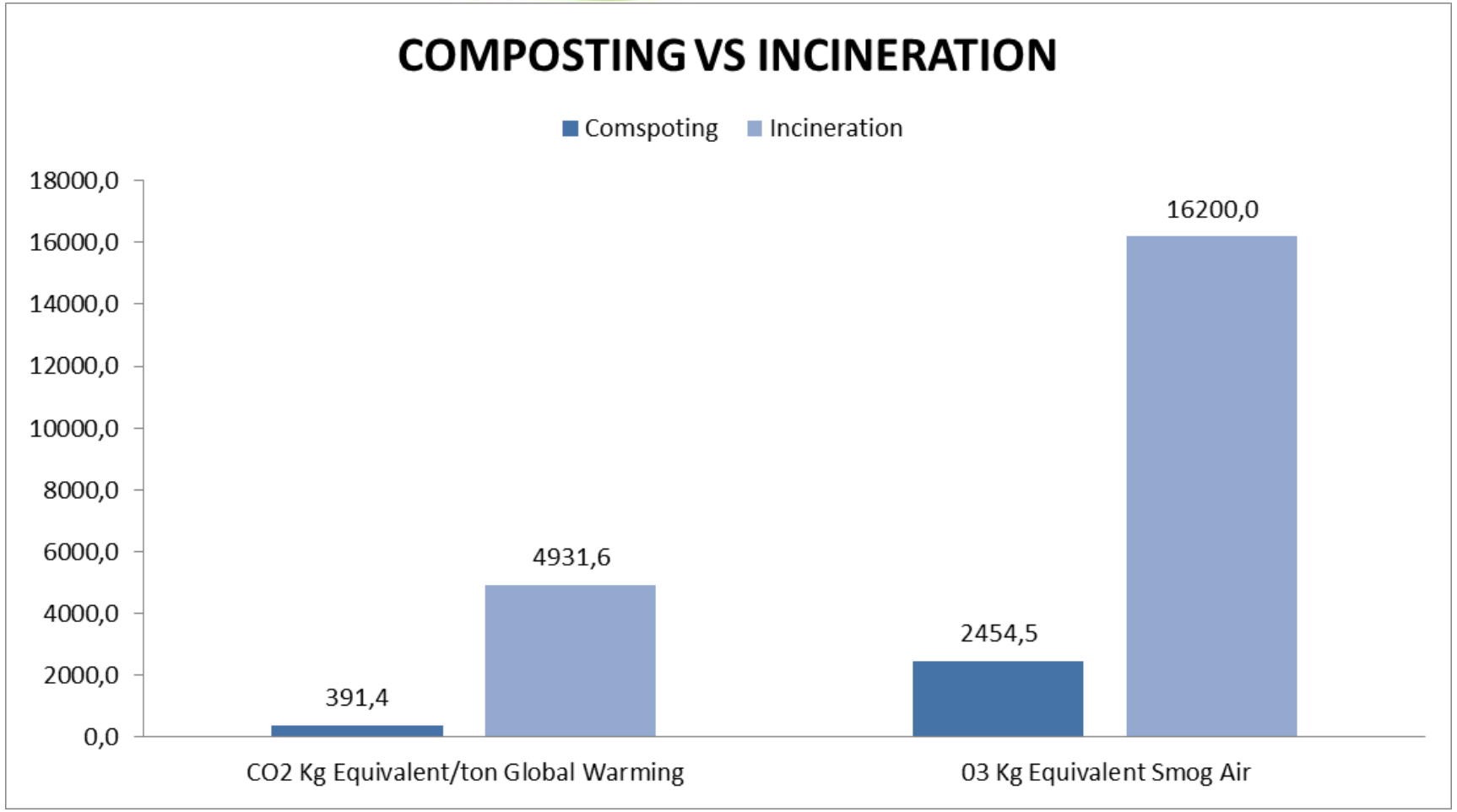


Modeled Human health criteria of composting. Y-axis marks units in Kg PM10 Equivalent.



Modeled potential of the Smog in Air of composting. Y-axis marks the units in Kg 0_3 Equivalent.

Results of the study



Results of the study

Klaipeda County

- Arable land 54666,2 ha, **compost fertilization can not be used**;
- Forest land 36822,7 ha, only 25312,3 ha can be used as multiple use for forestry, **compost fertilization can be used in 760 - 1266 ha** ;
- Abandoned land 609,3 ha, **compost fertilization can be used in 100% area**;
- In total at Klaipėda County it can be used compost fertilization in 1875,3 ha area, using fertilzation rate of 7-15 t/ha, thus **13127 - 28130 tons of compost / per 2-3 year** (data by Karčauskienė, 2021)**;**
- With this rate of fertilization **wastewater treatment plant could use in agriculture every year up to 6500 – 14 000 tons of sewage sludge compost** (yearly production ~ 2400 tons of dry mass = approx. 5000 tons of compost).

Conclusive remarks

- The composting of the sewage sludge produced at “Klaipedos vanduo” only slightly increases the concentration of heavy metals due to increase of dry mass;
- The increase of heavy metals concentrations in compost can be controlled using the removal techniques such as phytoremediation or other (i.e. citric acid, etc.);
- The LCIA modelling of the sewage sludge composting shows the environmental emissions less by 7.2 times comparing to the incineration of compost;
- Analysis of the compost applicability at Klaipeda district reveals that compost can be used in agricultural areas, that would lead to gradual reduction of the stockpiled compost quantities at “Klaipedos vanduo” sludge sites.

Thank you! ☺