

CHEM-E8125  
Synthetic Biology

# Biosensor for lead detection in Baltic Sea waters



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# Motivation & Background

## What?

The Baltic Sea is one of the most polluted bodies of water on Earth<sup>[1]</sup>

## Why?

The Baltic Sea is almost totally surrounded by land and therefore more endangered by pollution than other marine areas<sup>[2]</sup>.

## Sources of pollution:

Municipal and industrial waste (via rivers)

Atmospheric (from traffic and agriculture)<sup>[2]</sup>



*A shallow sea overloaded by man. Nine countries border the Baltic Sea<sup>[3]</sup>*

[1] <https://www.euronews.com/green/2021/09/28/europe-starts-cleaning-up-its-act-to-save-the-baltic-sea>

[2] <https://pubmed.ncbi.nlm.nih.gov/9722964/>

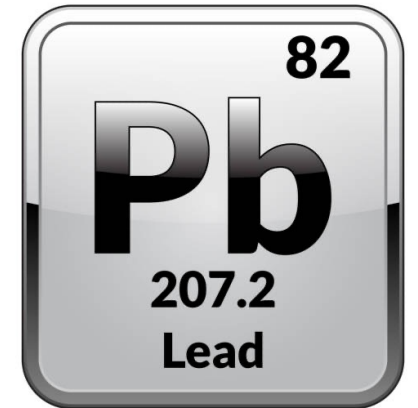
[3] <https://finland.fi/life-society/concern-for-a-precious-sea/>

# Motivation & Background

According to the set of acts of legislation published in Norway in 2017 **Hg, Cd, Pb, Cr** have been put on the revised list of priority pollutants<sup>[4]</sup>.

**Lead (Pb)** is a highly toxic metal in aquatic environments. Pb accumulation in fish tissues causes oxidative stress that induces synaptic damage and neurotransmitter malfunction in fish (neurotoxicity)<sup>[5]</sup>.

**Affordable bio-based solution:** biosensor for lead detection in Baltic Sea waters using *E. coli*



[4][https://www.researchgate.net/publication/343905198\\_Heavy\\_metal\\_pollution\\_in\\_the\\_Baltic\\_Sea\\_from\\_the\\_North\\_European\\_coast\\_to\\_the\\_Baltic\\_states\\_Finland\\_and\\_the\\_Swedish\\_coastline\\_to\\_Norway](https://www.researchgate.net/publication/343905198_Heavy_metal_pollution_in_the_Baltic_Sea_from_the_North_European_coast_to_the_Baltic_states_Finland_and_the_Swedish_coastline_to_Norway)

[5] <https://pubmed.ncbi.nlm.nih.gov/30884452/>

# Current methods for measuring environmental heavy metal pollutions and benefits of biosensors

- Currently classical analytical methods such as spectrometry, FIASS, ion chromatography and electrochemical techniques are used for measuring environmental heavy metals pollutions
  - + can detect metal ions with very good precision
  - quite expensive
  - take a lot of time
  - might require complicated preparations

Simpler methods are needed → **Biosensors**

- Heavy metals are in the biological systems either in toxic or non toxic-form and current methods can't distinguish between them but biosensors can →
  - + Biosensor can be used to monitor bioavailable (toxic) concentrations of heavy metals, even at very low concentration
  - + Provide useful information for bioremediation, waste-treatment plants and environmental impact –evaluation
  - + Easy to use, cheap, sensitive
  - + Microbes can overcome heavy metal pressure very quickly [6.]



[7.]



[7.]

# Selected parts

- **Lead detector unit**

- Constitutive promoter: BBa\_J23102
- Ribosome binding site: BBa\_B0032
- Lead binding protein: BBa\_I721002
- Terminators: BBa\_B0010 & BBa\_B0012

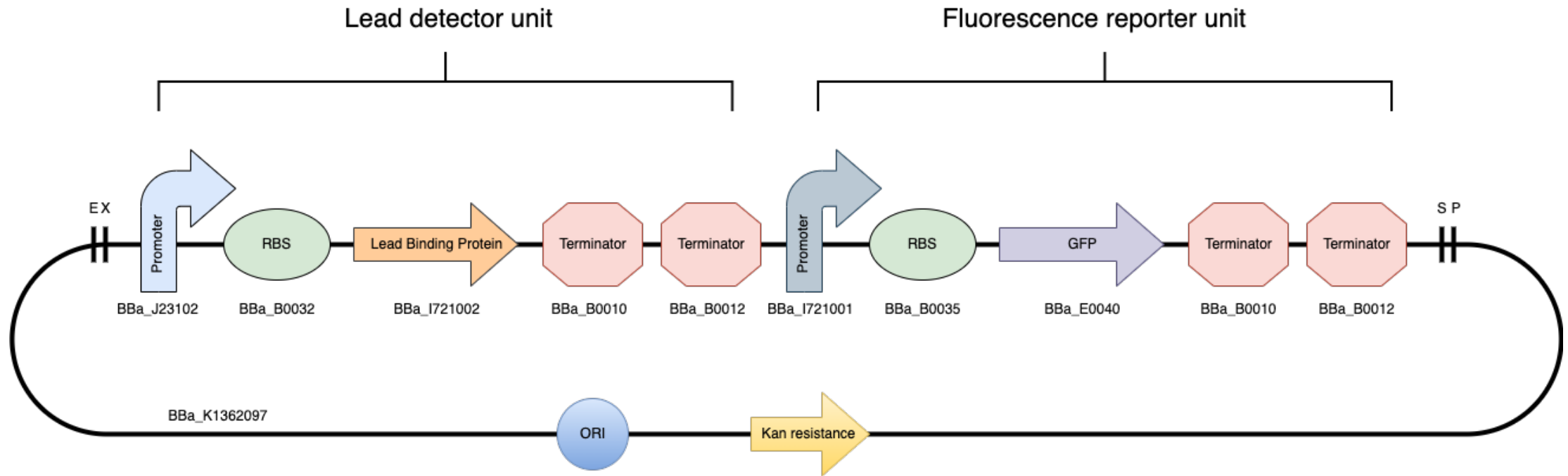
- **Fluorescence reporter unit:**

- Lead promoter: BBa\_I721001
- Ribosome binding site: BBa\_B0035
- GFP gene: BBa\_E0040
- Terminators: BBa\_B0010 & BBa\_B0012

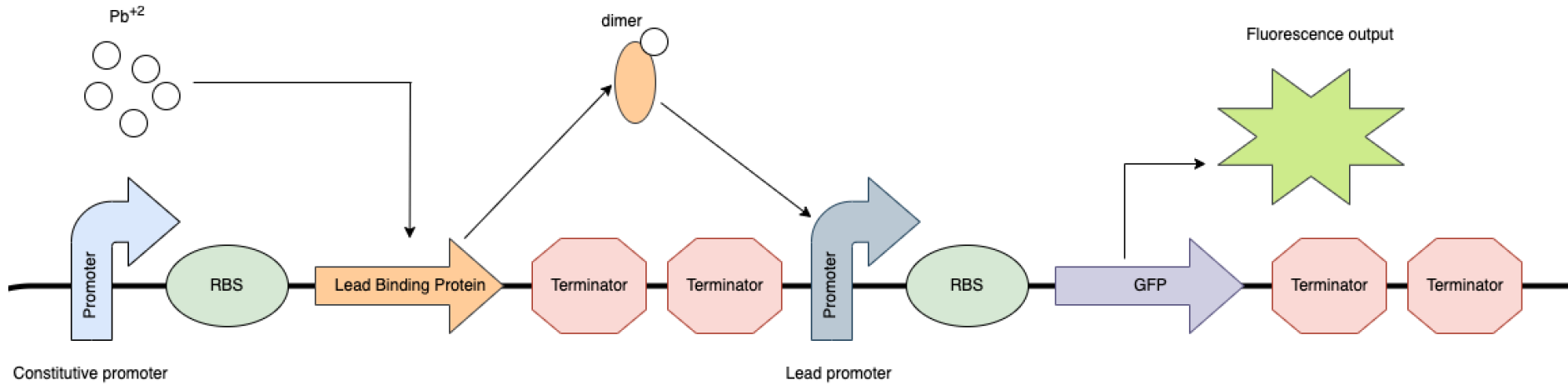
- **Backbone**

- BBa\_1362097 (Low copy BioBrick expression backbone carrying Kanamycin resistance)
- Chosen since BBa\_J23102 is a strong promoter and together with high copy plasmid it might cause burden to the cells <sup>[8]</sup>

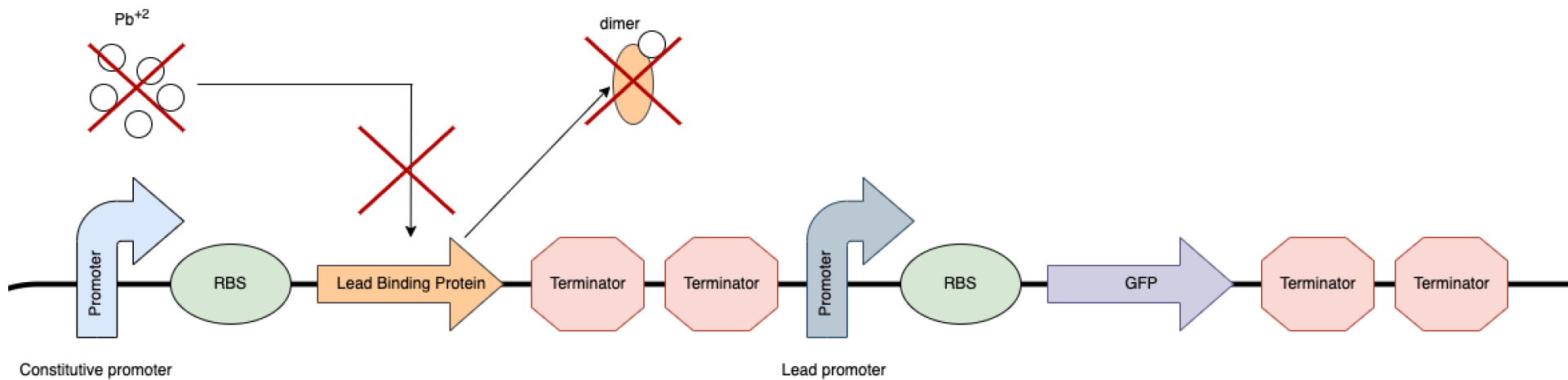
# Sensory construct and assembly



## ON state:



## OFF state:



Logic gate  
&  
Truth table



Pb <sup>2+</sup>	GFP
0	0
1	1





# Conclusions

- We designed a biosensor that can detect presence of lead in water samples
- Lead is very toxic and can cause eg. damage to aquatic animals →
- Important to monitor lead-levels in water system like Baltic Sea
- Biosensors are cheap, fast and can detect even small concentrations of lead



Thank you!

# References

[1] <https://www.euronews.com/green/2021/09/28/europe-starts-cleaning-up-its-act-to-save-the-baltic-sea>

[2] <https://pubmed.ncbi.nlm.nih.gov/9722964/>

[3] <https://finland.fi/life-society/concern-for-a-precious-sea/>

[4] <https://www.researchgate.net/publication/343905198> Heavy metal pollution in the Baltic Sea from the North European coast to the Baltic states Finland and the Swedish coastline to Norway

[5] <https://pubmed.ncbi.nlm.nih.gov/30884452/>

[6] Nourmohammadi, E., Hosseinkhani, S., Nedaeinia, R., Khoshdel-Sarkarizi, H., Nedaeinia, M., Ranjabar, M., Ebrahimi, N., Farjami, Z., Nourmohammadi, M., Mahdmoudi, A., Goli, M., Ferns, G. & Sadeghizadeh, M., Construction of a sensitive and specific lead biosensor using a genetically engineered bacterial system with a luciferase gene reporter controlled by pbr and cadA promoters, BioMed Eng OnLine. 19 (2020), <https://doi.org/10.1186/s12938-020-00816-w>

[7.] Powerpoint image library

[8] <https://www.frontiersin.org/articles/10.3389/fbioe.2020.00551/full>

[9] [http://parts.igem.org/Part:BBa\\_J73012](http://parts.igem.org/Part:BBa_J73012)