

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^[1]

Why?

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

Sources of pollution:

Municipal and industrial waste (via rivers)

Atmospheric (from traffic and agriculture)^[2]



A shallow sea overloaded by man. Nine countries border the Baltic Sea^[3]

[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/>

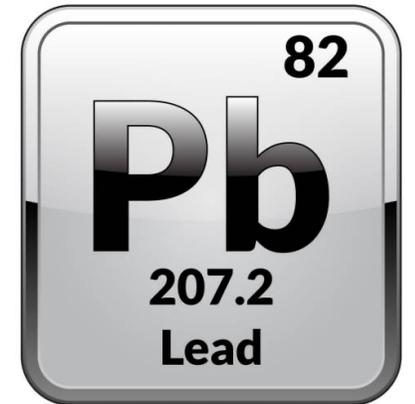
[3] <https://finland.fi/life-society/concern-for-a-precious-sea/>

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^[4].

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)^[5].

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

[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

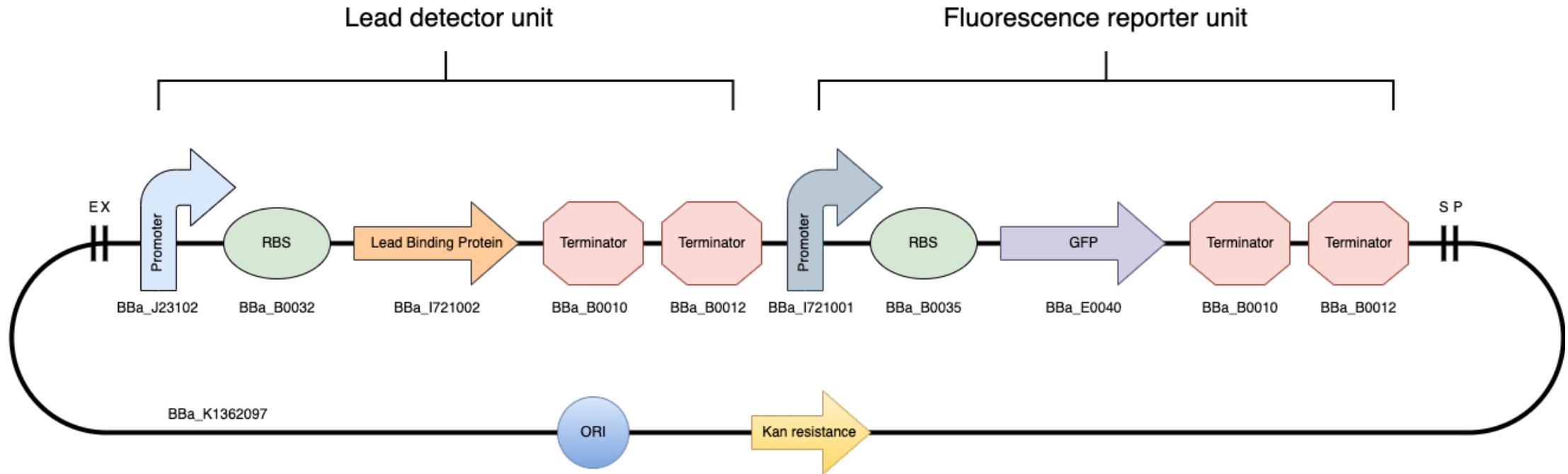
- **Fluorescence reporter unit:**

- Lead promoter: BBa_I721001
- Ribosome binding site: BBa_B0035
- GFP gene: BBa_E0040
- Terminators: BBa_B0010 & BBa_B0012

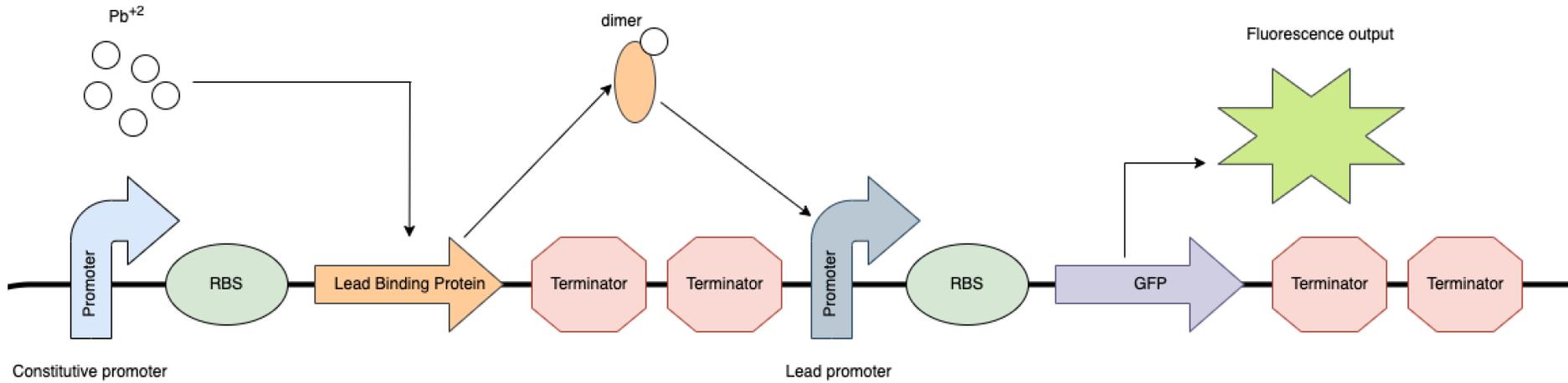
- **Backbone**

- 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 ^[8]

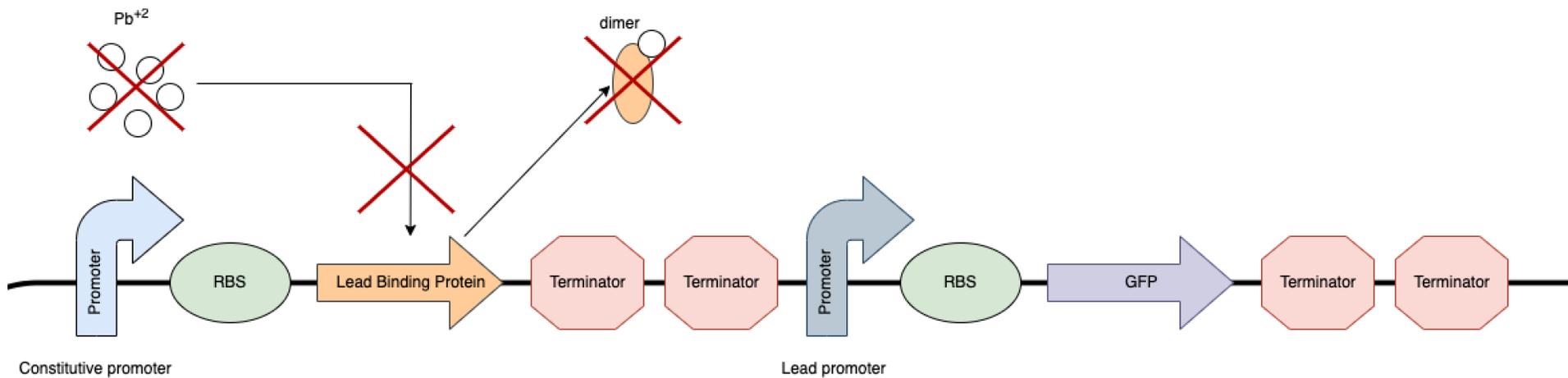
Sensory construct and assembly



ON state:



OFF state:



Logic gate
&
Truth table



Pb ²⁺	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