GLOBE Regional Learning Expedition

The non-devilish deeds of the Devil's Island - Hydrological studies on the Käsmu Peninsula

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1. ABSTRACT

We wanted to find out if Devil's island influences the water chemistry of Rotten Bay and Käsmu Bay, also we wanted to know which bay's chemical status is better. For this, we did fieldwork in four different sites, two sites in Rotten Bay and two in Käsmu Bay, near Käsmu Peninsula, Lääne-Viru County, Estonia.

Figure 1. The location of Käsmu Peninsula in Estonia (Google Maps, 2022)

Our Hypotheses were:

1. The Devil's island affects the water temperature and the oxygen level in Käsmu Bay positively.
2. It is better to swim in Rotten Bay because of higher water transparency and warmer water.
3. The Devil's island influences the water chemistry of the bays.

We used the GLOBE Program´s hydrology protocols to analyze the water parameters. The analyzed parameters were: water temperature, dissolved oxygen, pH level, conductivity, alkalinity, nitrates and transparency.

In the end, out of our three hypotheses one was proven true and two were proven partially true.

2. INTRODUCTION

The sea is used for swimming, fishing, boat rides etc. The needs of the people who take part in sea activities are different, but in most instances, people want warm and clear water.

The Käsmu Peninsula is located in Northern Estonia and is one of the pearls of the Lahemaa National Park. To the north of the Käsmu peninsula is Kuradisaar (Devil's Island), to the left is Mädalaht (Rotten Bay) and to the right is Käsmu Bay. The Käsmu Bay is more open to the winds, and is deeper than the Rotten Bay. Islands, big rocks and shoreline changing dynamics can affect the water quality (Ratas et al. 2008; Grudzinska *at al*., 2013; Figure 2).

We investigated the hydrological parameters of Rotten Bay and Käsmu Bay to consider the possible usage opportunities.

We wanted to know how Devil's island affects the water chemistry of the two bays and which bay's chemical status is better. Thus the hypotheses came to mind. The main winds in the area are North-East and East winds and Devil's island protects Rotten Bay from these winds. Due to this we thought that Devil's island affects the water temperature and the oxygen level in the Käsmu Bay positively, that it is better to swim in the Rotten Bay because of the higher water transparency and warmer water, and that Devil's island influences the water chemistry of the bays significantly.

3. RESEARCH LOCATIONS

We studied four different research sites on the shore of the Käsmu Peninsula. Two research sites are in Rotten Bay and two are in Käsmu Bay. These two bays are separated by Devil's island.

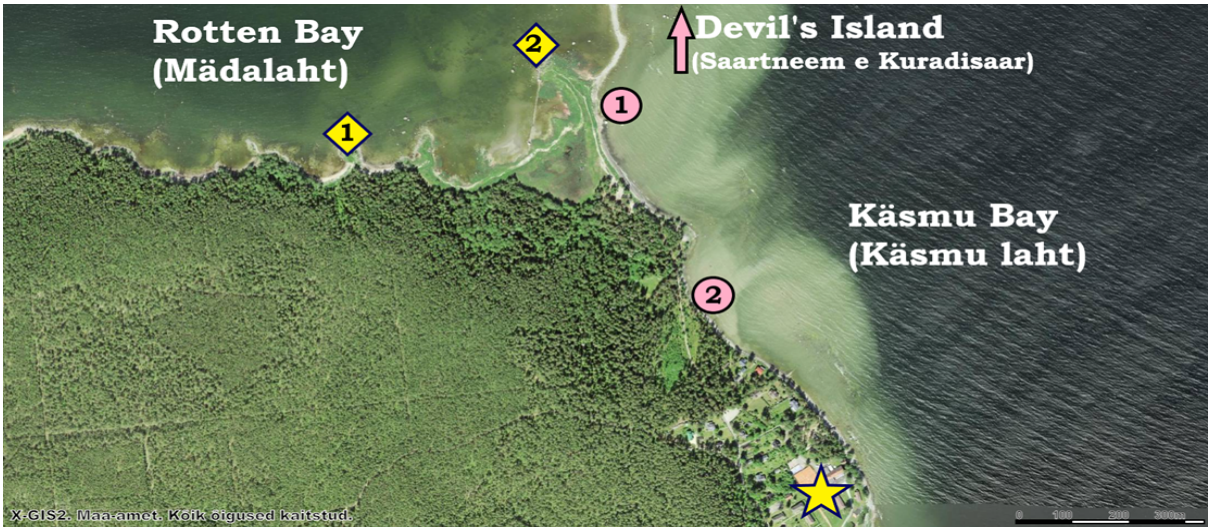

Figure 2. Sampling points near the Käsmu Peninsula. Yellow 1, 2 - sampling points in the Rotten Bay; Pink 1, 2 - sampling points in the Käsmu Bay. Yellow star - holiday village (Estonian Land Board, 2022 with author additions).

Figure 3. Site 1 in Rotten Bay

Figure 4. Site 2 in Rotten Bay

Figure 5. Käsmu Bay

In all of the sampling sites the water was open to the sun. The sampling sites in Rotten Bay were rockier compared to the sites in Käsmu Bay which were mostly sandy.

4. MATERIALS AND METHODS

We conducted fieldwork and analyzed the samples on 3 August 2022 between 2.00 PM and 7.00 PM (EEST, GMT+2). We followed the GLOBE hydrology protocol for the study. At every sampling point, we analyzed 3 subsamples and took the average of the results. All of the samples were analyzed *in situ* with chemical kits and electronic probes. At each research site, we also took atmospheric measurements (air temperature, cloud cover, barometric pressure, humidity) according to the GLOBE atmosphere protocol.

We used the Vernier sensors:

- for water temperature,
- for pH,
- for conductivity,

For measuring water transparency, a transparency tube was used.

The chemical analysis we used different kits:

- for dissolved oxygen: Visocolor HE,
- for alkalinity: Visocolor HE,
- for nitrates: Visocolor ECO.

5. RESULTS

For a better overview, we gathered the collected data into tables and graphs. Here, a table of all hydrological measurements in all sampling sites will be presented (Table 1). Graphs comparing water temperature, dissolved oxygen and water transparency at the sampling sites will follow (Figures 6-8). We compared only these parameters because they were essential to test our hypotheses.

Table 1. Results of analyzed samples from the research sites.

Results	**Rotten bay site 1**	**Rotten bay site 2**	**Käsmu bay site 1**	**Käsmu bay site 2**
Sampling time, UTC	11:49	12:29	13:02	13:43
Water temperature, °C	21.8	24.1	21.8	22.3
Dissolved oxygen, mg/l	9	10	9.6	10.2
pH	8.5	8.5	8.2	8.4
Conductivity, µS/cm	9683	9256	9799	9712
Alkalinity (HCO_3^-), mg/l	93.5	85.4	109.8	105.7
Nitrates (NO_3^-), mg/l	1	1	1	1
Transparency, m	>1.2	>1.2	0.8	0.5

The most important results were: slightly higher water temperature in Rotten bay site 2 (24.1 °C), lower transparency in Käsmu bay - 0.8 m in site 1 and 0.5 m in site 2, almost equal amounts of dissolved oxygen in all sites - the highest 10.2 mg/l in

Käsmu bay site 2 and the lowest 9 mg/l in Rotten bay site 1.

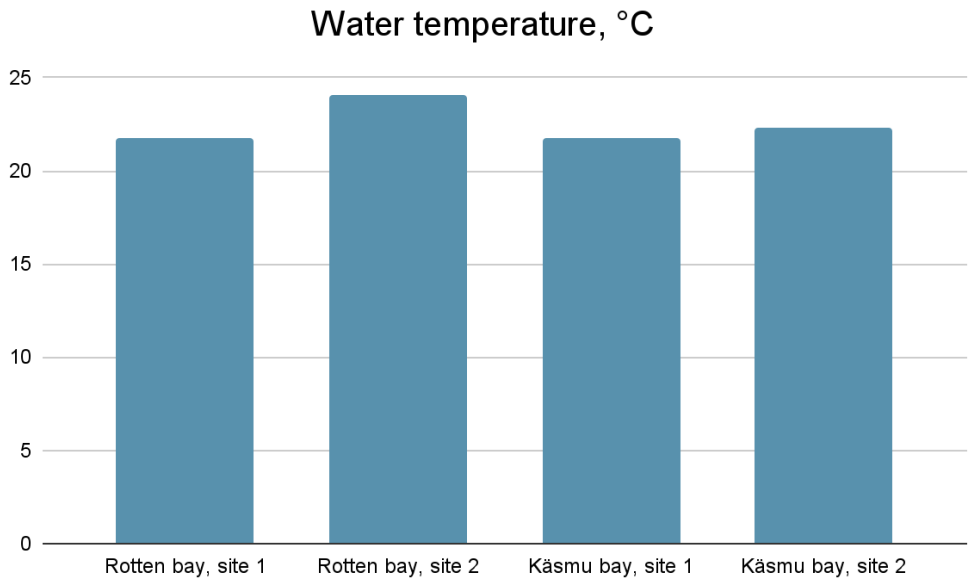

Figure 6. Water temperature in sampling sites.

The highest temperature was in Rotten Bay site 2 (24.1°C) and the lowest temperature in Rotten bay site 1 and Käsmu bay site 1 (21.8°C). When comparing the measurements in each site, the only notable difference was the slightly higher temperature in Rotten Bay site 2.

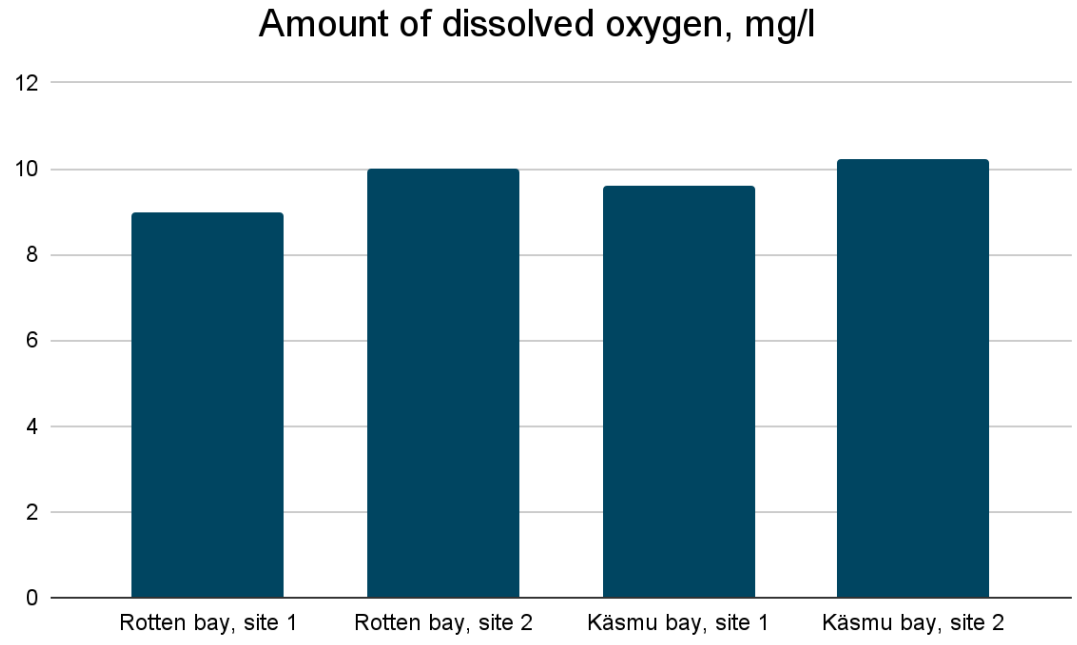

Figure 7.The amount of dissolved oxygen in sampling sites

The highest amount of dissolved oxygen was in Käsmu bay site 2 (10.2 mg/l) and the lowest amount in Rotten bay site 1 (9 mg/l). Overall there was no big difference in the results.

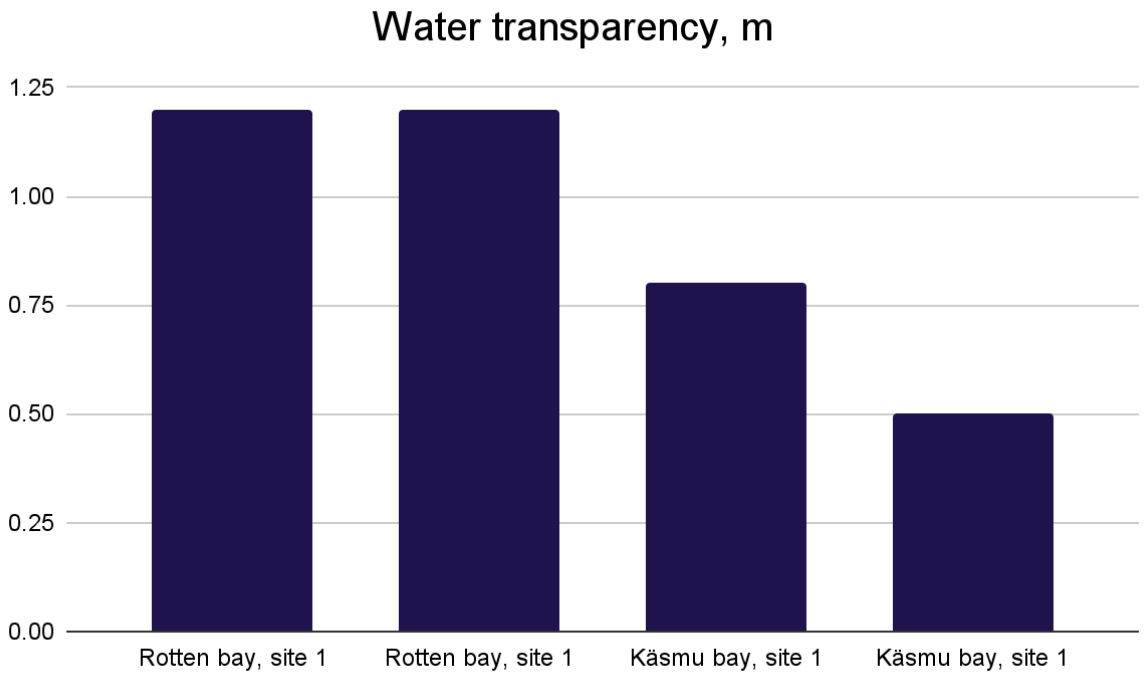

Figure 8. Water transparency in sampling sites

We found that the water transparency was much higher in Rotten Bay than it was in Käsmu Bay. This difference may be due to the influence of waves and/or microalgae in Käsmu Bay.

6. DISCUSSION

Our research showed that the chemical statuses in Käsmu Bay and Rotten Bay don't differ greatly. The results were in a normal range compared to the Baltic Sea for almost all parameters.

Water temperature was similar (21.8-22.3 °C) in all sites except for site 2 (24.1 °C) in Rotten Bay. There was no a notable difference in dissolved oxygen, although on average the values were higher at Käsmu Bay. The results were in a normal range for a sunny day.

The pH was normal for the Baltic Sea (normal range: 8-8.6; Havenhand et al., 2018). Conductivity was normal for the region (normal range: 4000-12000 uS/cm; Chrzan & Abdi, 2007). Alkalinity was in a normal range (normal range: 80-200 mg/l; Hjalmarsson *et al*., 2008). The nutrient content (measured as nitrates NO3-, mg/l) was lower than expected (HELCOM, 2009).

Nitrates were normal although on the low side of the range (normal range: 0.2-3 mg/l). Transparency was normal at the first two sites in Rotten Bay (>1.2 m) but low at the third (0.8 m) and fourth site (0.5 m) in Käsmu Bay. We think that this difference may be caused by waves, detritus, as well as differences in sand and plants.

7. CONCLUSION

Hypothesis 1 was partially supported. Käsmu Bay is deeper and open to the winds so the water is colder. The Devils Island protects the Rotten Bay from the North-East winds so the water is warmer. On average the dissolved oxygen is higher in Käsmu Bay.

Hypothesis 2 was supported. Rotten Bay has a significantly higher water transparency and a higher water temperature (at the second site) than Käsmu Bay, which makes it more suitable for swimming.

Hypothesis 3 was partially supported. We found a few minor differences between the water chemistry of Käsmu Bay and Rotten Bay. For example, the transparency was better in Rotten Bay. The island likely caused these differences. The Devil's island's influence is probably greater on the hydrophysical parameters (waves, currents, etc).

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