

Skýrsla nr. 2023-022

27.12.2023



Fecal bacteria concentration around Veitur's WWTPs in Borgarbyggð

**Report on fecal bacteria samples from Bifröst, Varmaland,
Reykholt and Hvanneyri**

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Útdráttur In this study, the values of fecal bacteria from Bifröst, Varmaland, Hvanneyri and Reykholt at outfall were compared to the limit values set by the government to determine their compliance with regulations. The findings indicate that Reykholt and Bifröst are not causing a potential risk to the public, but Hvanneyri and Varmaland have higher values than the set limit and future investigations should take place to lower the number of released bacteria to the environment, so the health risk is minimized when the public encounters the outfall area.		
Efnisorð Fecal Bacteria, Bifröst, Varmaland, Hvanneyri, Reykholt, Borgarbyggð		Yfirlit

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1 Introduction

Veitur is responsible for treating sewage in the whole of Reykjavik and some places in the west of Iceland. In the west, there are 4 secondary treatment plants with a biological treatment process. The influent is first separated from unwanted particles and then sent to the Rotating Biological Contactors (RBC). The RBC allows microorganisms to reduce the amount of biodegradable matter and nutrients in the water. It was recommended to Veitur to have some kind of disinfection device after the RBC to reduce the number of microorganisms, due to the risk they might pose to the environment in all 4 treatment areas. (Sebastian Lindel, 2022). In all of Veitur's wastewater treatment plants in the west, some kind of UV disinfection is in place. In Reykholt and Hvanneyri, a UV pond is used so the sunlight can break down the microbes. At Bifröst and Varmaland, due to a lack of space, a UV radiation device is used. (Þórarinsdóttir & Brynjúlfsson, 2012)

As mentioned before, there is a risk of contaminating the environment with fecal microorganisms. These microorganisms don't thrive in an open environment, but in case of contact with humans, they can cause diseases and health issues. Therefore, it is necessary to keep track of the number of microorganisms released into the environment.

The main purpose of this report is to offer a better understanding of the sampling procedure regarding the health risk to the public of the discharged effluent from the treatment plant to the environment. The samplings were taken at 4 treatment plants in the western part of Iceland. These data are not used to find out the efficiency of the treatment plant. However, if the concentration of the detected microorganism is greater than the limit values, safety precautions should be taken to prevent any possible danger to public health.

2 Sampling

At each of the places, there was a sampling scheduled each month to test for indicator bacteria. It is important to keep this ongoing sampling. This does not prevent contamination of the environment but can help detect the contamination and therefore inform authorities and the public about possible health risks and prevent them from becoming sick.

2.1 Sampling period

The sampling period started in September 2022 and is scheduled to continue until Veitur decides to stop sampling. The results presented are from the period of 27/09/2022 to 15/11/2023. The exact dates of the samples can be seen in a table below for each sample.

Bifrost	Varmaland	Reykholt	Hvanneyri
27/09/2022 11:30	27/09/2022 12:20	27/09/2022 13:40	27/09/2022 14:20
10/10/2022 14:40	10/10/2022 15:00	10/10/2022 15:20	10/10/2022 15:50
07/11/2022 15:25	07/11/2022 15:10	07/11/2022 14:45	07/11/2022 14:15
15/12/2022 13:00	15/12/2022 13:20	15/12/2022 13:50	15/12/2022 14:25
15/02/2023 12:00	15/02/2023 12:00	15/02/2023 13:00	15/02/2023 14:00

29/03/2023 12:20	29/03/2023 12:40	29/03/2023 13:00	29/03/2023 13:30
25/04/2023 14:00	25/04/2023 14:30	25/04/2023 15:10	25/04/2023 16:00
24/05/2023 14:15	24/05/2023 14:35	24/05/2023 15:00	24/05/2023 15:30
20/06/2023 12:05	20/06/2023 13:35	20/06/2023 14:20	20/06/2023 15:00
28/07/2023 13:45	28/07/2023 14:05	28/07/2023 14:30	28/07/2023 15:00
09/08/2023 13:00	09/08/2023 13:25	09/08/2023 13:50	09/08/2023 14:20
25/9/2023 12:50	25/9/2023 14:20	25/9/2023 14:40	25/9/2023 15:15
11/10/2023 12:30	11/10/2023 13:00	11/10/2023 13:30	11/10/2023 14:3-00
15/11/2023 13:55	15/11/2023 13:55	15/11/2023 13:55	15/11/2023 13:55

Table 1 Dates of when the samples were taken.

However, only the sampling results from dates marked in light blue in table 1 are going to be considered reliable, since the sampling position was changed. Due to the harsh winter conditions in January 2023, no samples were taken for that month. It was evaluated as too dangerous, and following Veitur's Health and Safety policies, staff's life and health have a higher priority than anything else. (Veitur, 2023)

2.2 Testing methods and target elements

The samples are taken to test for indicator bacteria such as fecal coliform (Hitapólnir kólígerlar) and fecal cocci (Saurkokkar). To test for the indicator bacteria, the quanti tray was used in both cases as one of the easiest, fastest, and cheapest ways to indicate these bacteria.

2.3 Sampling areas and locations

In the 2022, there were 4 different sampling areas: Bifröst, Varmaland, Reykholt, and Hvanneyri. Sampling locations for Reykholt and Hvanneyri were changed in April 2023. The change of locations was not initiated to find ideal samples to comply with the set limit but to find more reliable data that actually reflects the health risk to the public. Effluent concentrations within fenced areas are not, in Veitur's view, the appropriate values for such evaluation. For each of them, a picture is provided of the exact sampling point to ensure that in the future the information is available in case it is going to be needed.

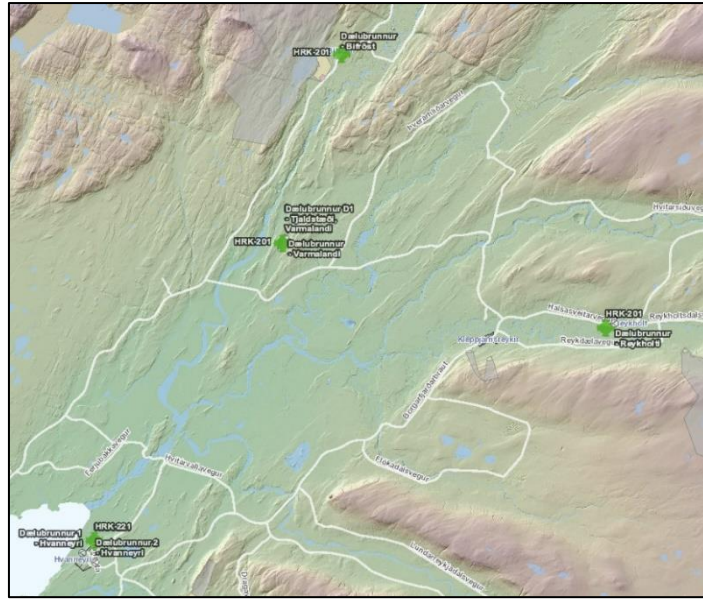


Figure 1 Sampling Areas: Bifröst, Varmaland, Reykholt and Hvanneyri.

2.3.1 Bifröst

The samples from 27/09/2022 till 15/11/2023 were taken after the treatment where the effluent from the treatment plant enters the environment at the location marked with an orange circle shown in the figure below number 2. The effluent is discharged into the porous lava via an infiltration pit.

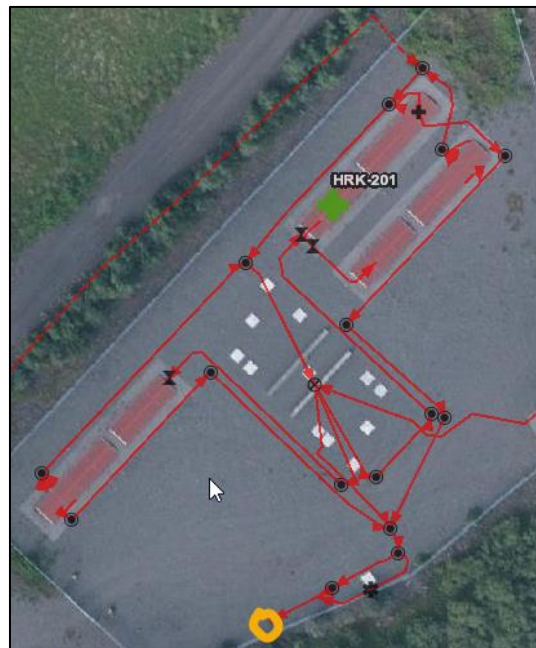


Figure 2 Sampling locations at Bifröst

2.3.2 Varmaland

All samples from 27/09/2022 until July 2023, were taken in the manhole marked with a purple circle. The location was changed in July 2023 and the sample is taken in a swale outside of the

fenced area of the treatment plant, where the public can get in contact with the effluent. The actual sampling location is marked with an orange circle.



Figure 3 Sampling locations at Varmaland

2.3.3 Reykholt

Originally, the sample was taken right after the treatment plant before the effluent was discharged into the river. It is marked with a purple circle in the picture, but this sampling location is not accessible to the public. The sampling location was changed in April 2023 so the sample would be taken from water which the public might encounter. The sample is taken downstream, in the river, where the effluent is being discharged and diluted with the water.



Figure 4 Sampling locations at Reykholt

2.3.4 Hvanneyri

At Hvanneyri, at the beginning the sampling was done inside the area of treatment plant which did not reflect the true impact on the environment and health risk to the public, because the sampling location was not accessible to the public. Same as in Reykholt, it was decided to take the samples a bit further from the UV pond. There were 2 samples taken in the swales close to the discharge point of influent for each sampling period. The purple mark in the figure below shows the original location of sampling and the orange circle marks the latest sampling locations.



Figure 5 Sampling locations at Hvanneyri

3 Result of the samples

Since the location of sampling has changed throughout the sampling period to provide more reliable and precise data, it was decided that for Hvanneyri and Reykholt the sampling results from 27/09/2022 to 25/04/2023 are going to be excluded from the conclusion and only data from 25/04/2023 to 15/11/2023 are going to be considered as reliable data. This is because the latter data is on concentrations in waters accessible to the public.

The limit value for the total number of bacteria in a 100mL sample is set to 1000 for both fecal coliforms and fecal cocci. (Jóhannesson, 1999). However, Veitur aims to keep the number of bacteria below 500, which is the highest limit defined by fecal bacteria concentration for seawater in the Icelandic bathing regulation (Ministry of the Environment, Energy and Climate, 2015). Therefore, in the tables shown below, the amounts of bacteria were divided into 3 different colours. Green represents the values that fulfill the limit requirements for both Veitur and Icelandic regulations, yellow values comply only with Icelandic regulations and red exceeds both.

In total, 50 samples were taken (64 with the excluded ones) to test for indicator bacteria. In February 2023, 6 samples out of 8 taken from the sampling locations at that time resulted in higher values than the set limit, and 4 of them had the highest number of bacteria for the whole sampling period at that specific location.

For fecal coliforms (hitapólnir kólígerlar), out of 50 results, 32 were under the limit value and 18 had a higher count of bacteria than the limit. That makes a 64% success rate. However, 12 out of the 18 non-compliant results were taken at Hvanneyri. The graph below shows the number of fecal coliforms at all the testing areas and how they changed throughout the testing period.

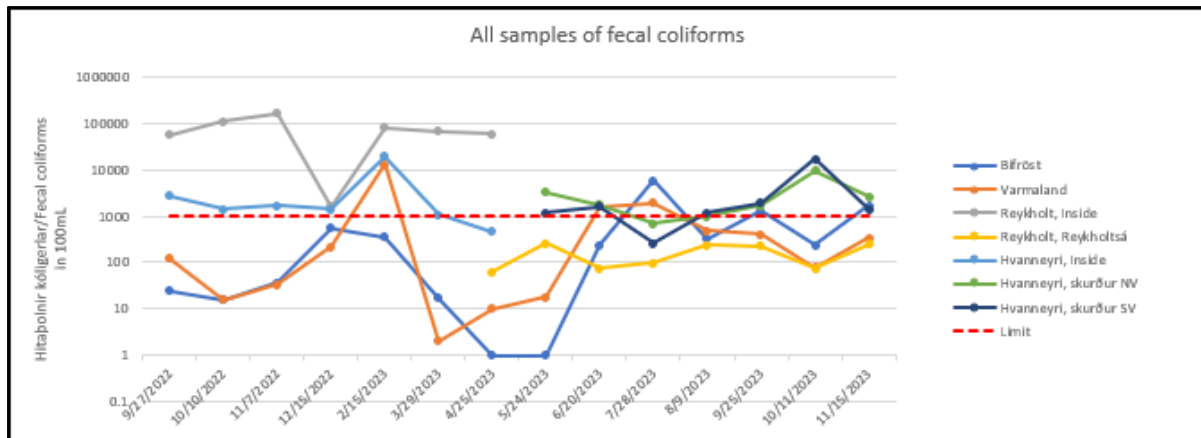


Figure 6 Graph of fecal coliforms values

Fecal cocci had a better success rate of 88%. 44 out of 50 samples had a lower number of bacteria than 1000 and only 6 exceeded the limit. It all can be seen in the graph below.

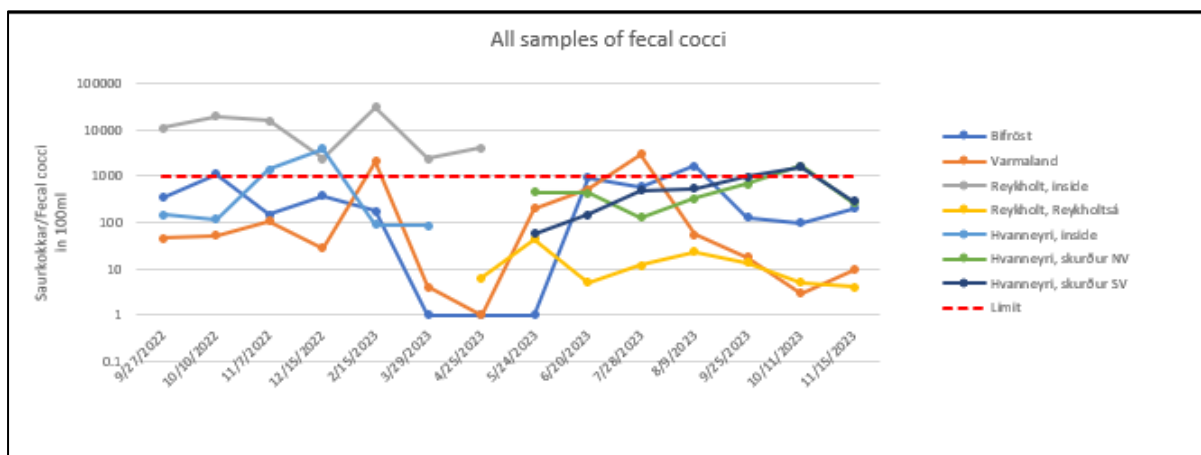


Figure 7 Graph of fecal cocci values

Table 2 Total number of samples under and over the limit value

Fecal coliforms	Including REY&HVA before April	Excluding REY&HVA before April
Total samples taken	64	50
Total bad	31	18
Total good	33	32
Under limit	52%	64%
Fecal cocci	Including REY&HVA before April	Excluding REY&HVA before April
Total samples taken	64	50
Total bad	15	6
Total good	49	44
Under limit	77%	88%

3.1 Bifröst

Bifröst came out with mostly positive results. For the fecal coliforms there were 3 samples where the total count of bacteria exceeded the limit value of 1000. For the fecal cocci, there were 2 samples that exceeded the limit value.

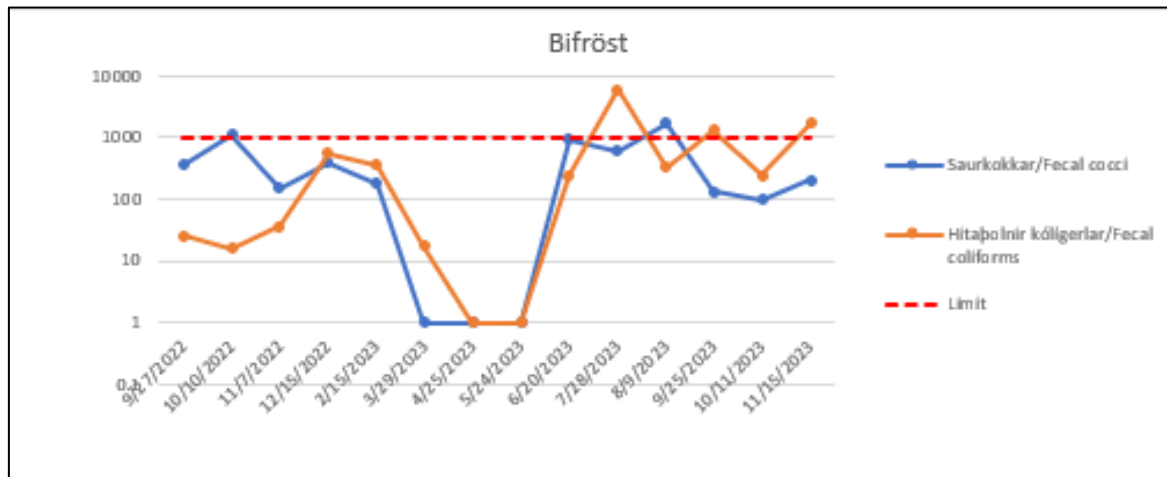


Figure 8 Results of samples taken at Bifröst

The average amount of bacteria in one sample came out to be at 757.57 for fecal coliforms and 415.07 for fecal cocci. Both average values are below the limit value. The exact values can be seen in the table 3 below.

Hitapölnir kólígerlar/Fecal coliforms	Bífröst
9/27/2022	25
10/10/2022	16
11/7/2022	36
12/15/2022	550
2/15/2023	350
3/29/2023	17
4/25/2023	0.999
5/24/2023	1
6/20/2023	240
7/28/2023	5800
8/9/2023	330
9/25/2023	1300
10/11/2023	240
11/15/2023	1700
Too high values	3
Alright values	11
Average	757.57
Saurkokkar/Fecal cocci	Bífröst
9/27/2022	350
10/10/2022	1100
11/7/2022	150
12/15/2022	380
2/15/2023	180
3/29/2023	1
4/25/2023	0.999
5/24/2023	0.999
6/20/2023	920
7/28/2023	600
8/9/2023	1700
9/25/2023	130
10/11/2023	98
11/15/2023	200
Too high values	2
Alright values	12
Average	415.07

Table 3 Table of samples taken at Bífröst

3.2 Varmaland

The samples at Varmaland came up with 3 samples exceeding the limit value for fecal coliforms and 2 samples for fecal cocci. Sample taken 15/02/2023 showed an unacceptably high value of 13000 bacteria per 100mL for a fecal coliform.

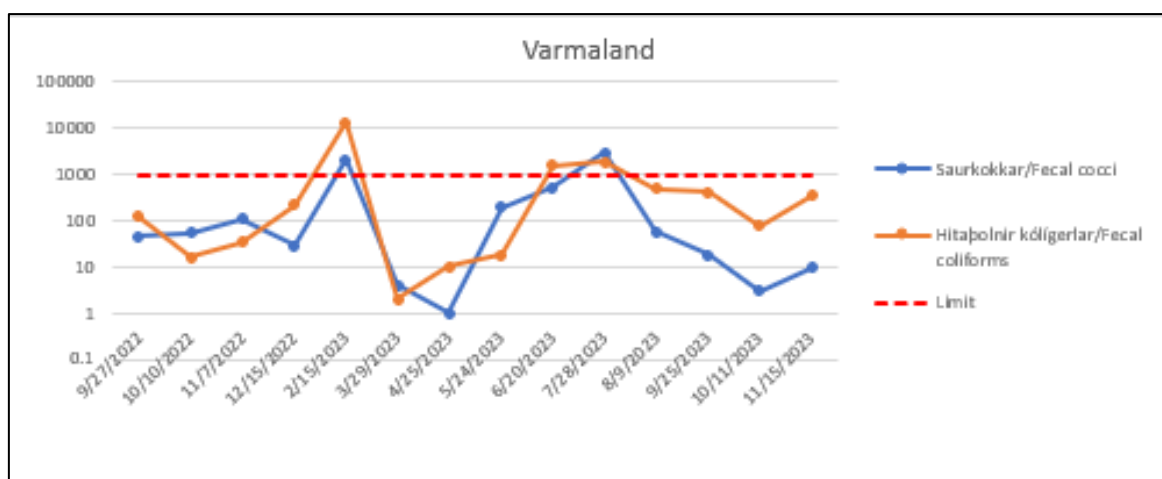


Figure 9 Results of samples taken at Varmaland

The average value at Varmaland for fecal coliforms was calculated to be 1302.79 which is over the limit and for fecal cocci it was 439.20 which is a safe value. Values are shown in the figure below.

Hitapólnir kólígerlar/Fecal coliforms	Varmaland
9/27/2022	120
10/10/2022	16
11/7/2022	34
12/15/2022	220
2/15/2023	13000
3/29/2023	2
4/25/2023	10
5/24/2023	18
6/20/2023	1600
7/28/2023	1900
8/9/2023	490
9/25/2023	410
10/11/2023	79
11/15/2023	340
Too high values	3
Alright values	11
Average	1302.79
Saurkokkar/Fecal cocci	Varmaland
9/27/2022	46
10/10/2022	53
11/7/2022	110
12/15/2022	28
2/15/2023	2100
3/29/2023	4.1
4/25/2023	0.999
5/24/2023	200
6/20/2023	520
7/28/2023	3000
8/9/2023	56
9/25/2023	18
10/11/2023	3
11/15/2023	9.7
Too high values	2
Alright values	12
Average	439.20

Table 4 Table of samples taken at Varmaland

3.3 Reykholt

From 27/09/2022 until 25/04/2023 all the results from the sampling came out to be highly over the limit for fecal coliforms and fecal cocci. Those results are from a sampling site not accessible to the public. Since the change of the sampling location in April 2023, none of the results showed a value higher than the limit. In fact, all of them were under the limit value set by the Veitur of 500 units/mL for both fecal coliforms and fecal cocci.

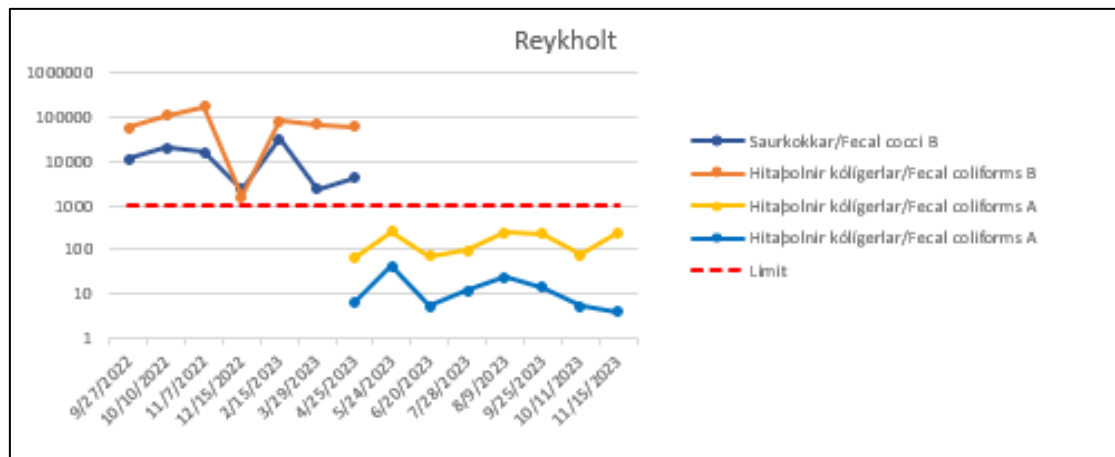


Figure 10 Results of samples taken at Reykholt

The average for Reykholt's old sampling location came up to be 78.800 units for fecal coliforms and 12.414,29 units for fecal cocci per 100mL. The average at a new sampling location is 161,25 units of fecal coliforms and 14,38 units for fecal cocci. All the values are shown in the table below.

Hítapólnir kólígerlar/Fecal coliforms	Reykholt, inside probably	Reykholt, Reykholtstá
9/27/2022	58000	
10/10/2022	110000	
11/7/2022	170000	
12/15/2022	1600	
2/15/2023	82000	
3/29/2023	69000	
4/25/2023	61000	63
5/24/2023		260
6/20/2023		74
7/28/2023		98
8/9/2023		240
9/25/2023		230
10/11/2023		75
11/15/2023		250
Too high values	7	0
Alright values	0	8
Average	78800.00	161.25
Saurkokkar/Fecal cocci	Reykholt, inside probably	Reykholt, Reykholtstá
9/27/2022	11000	
10/10/2022	20000	
11/7/2022	16000	
12/15/2022	2400	
2/15/2023	31000	
3/29/2023	2400	
4/25/2023	4100	6.3
5/24/2023		44
6/20/2023		5.2
7/28/2023		12.2
8/9/2023		24
9/25/2023		14
10/11/2023		5.2
11/15/2023		4.1
Too high values	7	0
Alright values	0	8
Average	12414.29	14.38

Table 5 Table of samples taken at Reykholt

3.4 Hvanneyri

Fecal coliforms total count per sample was almost always higher than the limit set by the Icelandic Ministry of the Environment, Energy and Climate even after changing the location from within the fenced area to the swales next to the discharge outfall. In the case of fecal cocci, the results were usually below the limit except for 4 samples, and two of them happened at the old sampling location. Since the location was changed, there were two values exceeding the limit of 1000 units per 100mL.

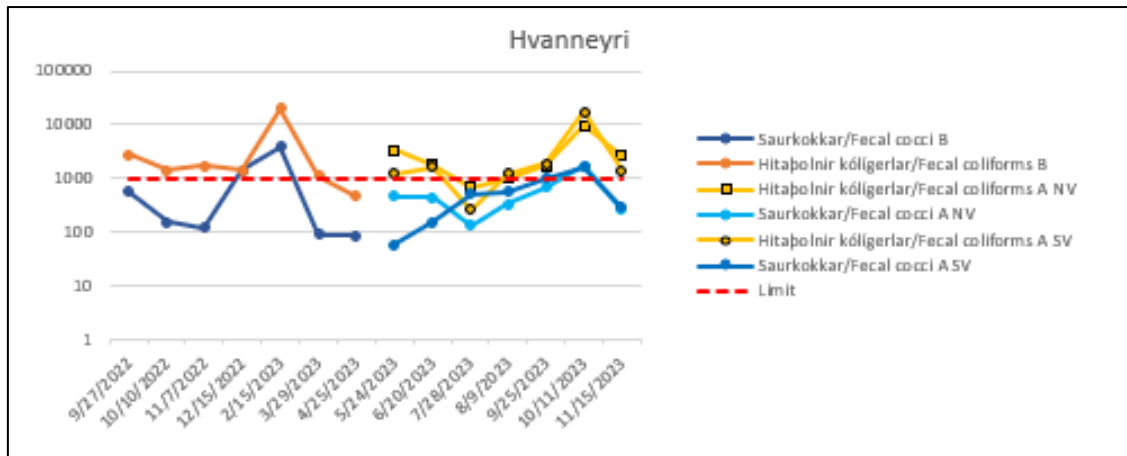


Figure 11 Results of samples taken at Hvanneyri

The average for fecal coliforms in the old sampling location was 4122,86. For the new location at north it was 2984,29 and at south 3508,57 units per 100MI.

Average for fecal cocci in the old location and new ones is below 1000. The old location's average is 899,43. At north it is 571,43 and at south it is 589,71.

Hitapolnir kóligerlar/Fecal coliforms	Hvanneyri, inside+last out	Hvanneyri, skurður NV	Hvanneyri skurður SV
9/27/2022	2800		
10/10/2022	1400		
11/7/2022	1700		
12/15/2022	1400		
2/15/2023	20000		
3/29/2023	1100		
4/25/2023	460		
5/24/2023		3300	1200
6/20/2023		1800	1600
7/28/2023		690	260
8/9/2023		1000	1200
9/25/2023		1700	1900
10/11/2023		9800	17000
11/15/2023		2600	1400
Too high values	6	6	6
Alright values	1	1	1
Average	4122.86	2984.29	3508.57
Saurkokkar/Fecal cocci	Hvanneyri, inside+last out	Hvanneyri, skurður NV	Hvanneyri skurður SV
9/27/2022	550		
10/10/2022	150		
11/7/2022	120		
12/15/2022	1400		
2/15/2023	3900		
3/29/2023	91		
4/25/2023	85		
5/24/2023		450	58
6/20/2023		440	150
7/28/2023		130	500
8/9/2023		330	550
9/25/2023		690	980
10/11/2023		1700	1600
11/15/2023		260	290
Too high values	2	1	1
Alright values	5	6	6
Average	899.43	571.43	589.71

Table 6 Table of samples taken at Hvanneyri

4 Discussion

To test for potential bacteria in the effluent, it is hard to pick a perfect location that would give a clear result of the impact and health risk to the public. There are many other factors that could affect the results. However, considering all the circumstances at each of the sampling areas, it looks like that from now on, the selected sampling locations should reflect the fecal bacteria concentrations in water accessible to the public quite well.

Bifröst results fluctuate more than is acceptable and have shown results with 5 samples out of 28 exceeding the limit value. There is a need for future investigation for a more appropriate sampling location. Now, the sample is taken in front of an infiltration soakaway, and that does not reflect the possible risk. There were two samples taken in the pond just below the infiltration soakaway at Bifröst in September and October 2023. Originally, the samples were also supposed to be taken from two ponds, but as it turned out, the pond on the left was just an old lava field and not a pond. Because the treatment plant has a higher elevation, it was expected to find some signs/remains of indicator bacteria in the samples if they are able to survive the underground journey at all. The results can be seen in the table below.

Table 7 Results from ponds below Bifröst

Hitapólnir kólígerlar/Fecal coliforms	Bifröst
9/25/2023	9.7
10/11/2023	0.999
Saurkokkar/Fecal cocci	Bifröst
9/25/2023	0.999
10/11/2023	0.999



Figure 12 Sampling locations at Bifröst for September

Varmaland's results were similar to those at Bifröst, with 5 samples exceeding the limit values out of 28. There is a camping site to the north of the treatment plant, and therefore the health risk is high. In addition to the load from the effluent, animals in neighboring grazing grounds might contribute to the bacteria concentration in the swale close to Veitur's discharge location.

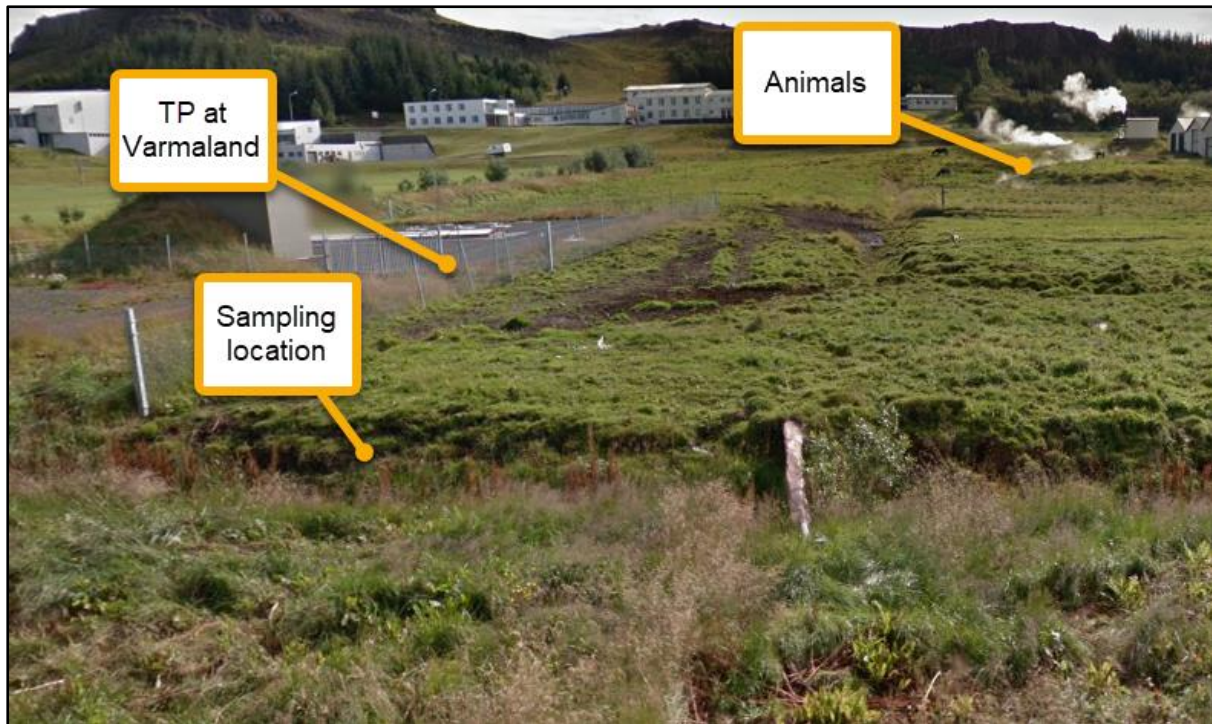


Figure 13 Varmaland sampling location

Rain could be one of the ways of how the bacteria travels/transport from fields where the animals are to the swale. In figure number 13, the swale where the sample is taken is probably around 80 centimetres deep, so it could mean that the rain infiltrates to the ground and gets naturally directed to the swale because of the elevation. A small illustration of the process can be seen in figure 14 below, where the area, elevation, and possible water direction are highlighted.



Figure 15 Hvanneyri NV



Figure 16 Hvanneyri SV



Figure 17 Hvanneyri SV downstream

In addition to the effluent from Veitur, a neighboring dairy production farm could be a source of the bacteria. The Agricultural University of Iceland has an animal stall located close to the sampling location. Veitur does not receive any wastewater from them, so it is assumed that the wastewater from the animal stall is treated and released into the environment locally.

Currently, there is no data on the efficiency of the UV ponds/UV devices at Veitur's treatment plants, which could also be a cause of higher bacteria values in the samples.

Some sampling locations were changed recently in August 2023, and some have remained the same since the beginning. If more data were accessible over a longer period, such as if samplings were taken for at least a few years, it might be possible to determine seasonal fluctuations from the graph and find a more cost-efficient way of running the treatment plants.

5 Conclusion

Samples taken from the pond south of the Bifröst treatment plant show that the effluent is efficiently diluted, significantly reducing bacteria levels to well below the limit. However, considering the pond's distance from the plant, identifying closer sampling locations would provide more immediate and representative data, ensuring continuous adherence to environmental standards.

Future investigations at Varmaland are necessary to understand the reasons behind the significant fluctuations in bacterial values. It is crucial to identify the factors contributing to these inconsistencies to ensure that effective measures can be implemented. Understanding the root causes of these fluctuations will not only enhance the treatment process but also contribute to the overall environmental health and safety of the area. These investigations will be key to maintaining a stable and safe effluent discharge, aligning with environmental standards and public health requirements.

If Reykholt maintains its current course of action, there should be no significant concerns regarding environmental pollution or harm. The consistent low levels of bacteria in samples from the actual location are reassuring. However, as a precautionary measure, it is advisable to post signs informing the public about the wastewater outlet. These signs will serve as an important tool for public awareness and health protection, ensuring that the community is informed about the presence of treated effluent and the ongoing efforts to maintain water quality.

The situation at Hvanneyri, however, presents a contrasting scenario and requires immediate attention. The consistently high levels of bacteria in the effluent are a cause for concern, and it is important to implement solutions to reduce these bacterial counts. If these high levels persist without effective intervention, it may become necessary to issue public warnings or impose restrictions to safeguard public health. Addressing this issue is not only crucial for meeting regulatory standards but also for maintaining the trust and safety of the community.

6 References

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