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Potable Water Quality on Non-Passenger Ships Calling Belgian Ports †

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Abstract: Waterborne disease due to the microbial contamination of potable water onboard ships is a potential threat for seafarers. The results from the samples collected at Belgian ports from 2010 to 2018 during inspections of non-passenger ships are used to evaluate the microbiological and chemical quality of potable water. A small proportion of the samples was found positive for indicator organisms (7.5%), indicating the lack of proper disinfection and possible contamination. Further analyses and risk assessments are recommended for examining possible contributing factors. Inspections for the issuance of SSC should focus on water safety and the prevention of waterborne diseases.

Keywords: microbiological parameter; chemical parameters; potable water; ships; SSC inspections

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1. Introduction

Waterborne diseases have been associated with water systems on ships and most reported outbreaks involve Norovirus and Enterotoxigenic *E. coli* [1,2]. The factors contributing to these waterborne outbreaks include contaminated bunkered water, inadequate disinfection, the ingress of grey/black water into potable water tanks, the use of seawater in the galley and contamination via cross-connections [1,2].

The World Health Organization's (WHO's) *Guide to Ship Sanitation* and *Handbook for Inspection of Ships and Issuance of Ship Sanitation Certificates* provide guidance for ships on international voyages with respect to various areas, including potable water [3,4]. The latter is used during inspections performed by competent port health authorities in order to issue a Ship Sanitation Certificate (SSC) within the framework of the International Health Regulations (IHR) [5]. During these inspections, the potable water system is inspected and samples are taken in order to verify compliance.

In this study, the results from the samples collected at Belgian ports from 2010 to 2018 during inspections of non-passenger ships are used to evaluate the microbiological and chemical quality of potable water.

2. Materials and Methods

The results of the microbiological analysis along with other information including the name of the ship, sample location, temperature and pH were provided by the Belgian port's health authority. Information related to the ships, including ship type, year build and flag, was acquired from an online database [6]. The classification of ship types followed the categories used in the EU Common Ship Sanitation Database [7].

3. Results

From 2010 to 2018, the port health authorities collected potable water samples for microbiological and chemical analysis on 3489 SSC inspections performed on board 2063 different ships calling Belgium ports. The total number of collected samples was 5640. Most samples were collected from 2012 to 2016 (71.9%).

Table 1 shows the number of samples collected for each parameter and the results of the analysis. From the 3471 different inspections where samples for microbiological analyses were collected, 260 (7.5%) had at least one positive sample for the parameters of Total Coliforms, *E. coli* and Enterococci. These samples were taken from 2056 ships and 229 (11.1%) of them had at least one positive sample. From the 108 different inspections where samples were collected for chemical analyses, 11 (10.2%) had at least one sample exceeding the parametric values of either Cd, Cu, Pb or Ni [8]. These samples were collected from 97 ships and 11 (11.3%) of them had at least one positive samples.

Table 1. Description of the data available for each parameter, acceptable levels and the number of samples outside the acceptable levels.

Parameter	Number of Samples	Min	Max	Mean	SD	Acceptable Level	Samples Outside Acceptable Levels (%)
Temperature (°C)	1551	7	60	23.0	4.6	≤25 [1]	347 (22.4%)
HPC at 22 °C (CFU/100 mL)	5601	0	47,000	635.4	1438.3	≤1000	1057 (18.9%)
HPC at 27 °C (CFU/100 mL)	934	0	35,000	772.4	2542.1	≤1000	166 (17.8%)
Coliforms (CFU/100 mL)	5506	0	1001	0.9	15.2	<1 [1]	252 (4.6%)
E. coli (CFU/100 mL)	5550	0	240	0.2	4.3	<1 [1]	65 (1.2%)
Enterococci (CFU/100 mL)	5529	0	109	0.1	2.6	<1 [1]	30 (0.5%)
pH	1550	4.9	10.8	7.8	1.1	6.5–9.5 [1]	330 (21.3%)
Conductivity (µS/cm)	1548	2	2460	208.4	255.9	2500 [1]	0 (0.0%)
Fe (µg/L)	132	20	18,700	683.5	2117.3	200 [1]	34 (25.8%)
Cd (µg/L)	130	1	20	1.2	1.7	3 [1]	1 (0.8%)
Cu (µg/L)	130	1	4410	292.8	596.8	2000 [1]	3 (2.3%)
Pb (µg/L)	130	1	273	6.511	33.5	10 [1]	8 (6.2%)
Zn (µg/L)	130	1	215.9	215.9	403.8	3000 [1]	1 (0.8%)
Ni (µg/L)	125	0	7950	75.1	710.2	70 [1]	3 (2.4%)

[1] Typical value according to WHO [3].

4. Discussion and Conclusions

Less than 5% of the samples were positive for Coliforms, fewer were found positive for *E. coli* and even less were positive for Enterococci. These positive samples correspond to a significant percentage of the ships inspected (11.1%). A similar study examined the microbiological quality of 342 ships calling UK and Channel Islands and reported that 6.76% of the samples were positive for Coliforms, 0.74% were positive for *E. coli* and 2.07% were positive for Enterococci [9]. The rate of ships with at least one of these parameters positive was reported to be slightly higher than the rate in the present study (16.1%).

Positive samples for Coliforms *E. coli* and Enterococci indicate poor sanitary conditions and the possible contamination of the potable water of those ships [10]. Inadequate treatment is also evident considering that HPC levels increased in many samples. The free residual chlorine measurements of potable water were not available. pH values were found outside the typical values for one out five ships. pH values that are larger than eight may hinder the effectiveness of chlorination and values lower than 6.5 may lead to corrosion [3]. Although the description of the samples did not explicitly specify whether the samples were collected from the cold or the hot water line, it can be safely assumed that the majority of samples were collected from the cold water line.

Eight of the ships were found with Pb levels exceeding the typical values as per WHO, indicating that lead materials may be present in the potable water system of these ships [3,10]. One-fourth of the ships were found with iron levels exceeding the typical values of WHO and few ships were found with nickel and copper exceeding the typical

values. This is most probably caused by corrosion in the piping system and low pH levels [3,10].

The results indicate that a significant number of the ships may have inadequate disinfection and a few of them were found with fecal contamination and chemical parameters above the parametric values. Additional analyses of the data may reveal associations of positive results with specific characteristics of the ship. Finally, an analysis of the data recorded in the EU Common Ship Sanitation Database may provide further insights on the relationship between the inspection findings and the positive results.

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