INTERNATIONAL MARITIME ORGANIZATION

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MARINE ENVIRONMENT PROTECTION COMMITTEE
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Agenda item 5

MEPC 74/INF.27
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**AIR POLLUTION AND ENERGY EFFICIENCY**

# Compilation and assessment of 281 cruise ship EGCS washwater samples

**Submitted by CLIA**

**SUMMARY**

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|---|---|
| *Executive summary:* | This document highlights the assessment of 281 exhaust gas cleaning system washwater samples against 54 test parameters, including PAHs and metals, for comparison to IMO washwater discharge criteria and selected national and international water quality standards and land-based wastewater discharge limits |
| *Strategic direction, if applicable:* | 1 |
| *Output:* | 1.12 |
| *Action to be taken:* | Paragraph 17 |
| *Related documents:* | MEPC 68/21/Add.1; resolution MEPC.259(68) and PPR 6/WP.1 |

## Introduction

1 The information contained in this document highlights the study of 281 EGCS washwater samples collected from cruise ships and analyzed against 54 test parameters, including Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals. DNV-GL Maritime Advisory Services compiled, reviewed and evaluated the laboratory test data against IMO washwater discharge criteria and compared the laboratory analysis reports against selected national and international water quality standards and land-based wastewater discharge limits to provide a broader perspective.

2 Washwater sample analysis shows that average PAH and Nitrate levels are well below IMO washwater criteria and there is little to no contribution from the Exhaust Gas Cleaning System (EGCS) process to concentrations of the number of trace metal parameters (Arsenic, Cadmium, Lead, Mercury, Selenium and Thallium). Sample analysis shows average washwater concentrations are below the limits for comparable land-based industrial point source waste water standards, e.g. the German Waste Water Ordinance and the EU Waste Gas Cleaning Water Standards. Average washwater concentrations also compare favorably

to water quality standards with strict criteria, e.g. the EU Surface Water Standards and WHO Drinking Water Guidelines.

3 The complete washwater sampling assessment, which is publicly available online,[1] provides an objective evaluation of washwater for consideration by the Committee in the ongoing review of the *2015 Guidelines for Exhaust Gas Cleaning Systems* and washwater discharge criteria.

**Background**

4 Appendix 3 to the 2015 Guidelines addresses washwater data collection and requests shipowners to sample and analyze inlet water (for background), water after the scrubber (but before any treatment system); and discharge water for specific parameters using EPA or ISO test procedures. Moreover, in paragraph 11.19 of document PPR 6/WP.20, the PPR Sub-Committee encouraged interested Member States and international organizations to undertake further scientific research and to submit results to future sessions to facilitate the work on the revision of the 2015 Guidelines.

5 The 281 samples compiled and assessed were taken from 53 Carnival Corporation EGCS-equipped cruise ships between 2016 and 2018 in order to better understand the quality of EGCS washwater and parameters present.

**Sampling and analysis methodology**

6 The sampling process incorporated shipboard training and US EPA-referenced sampling protocols for consistency in collection, sample integrity, transfer protocols, chain of custody procedures and documentation. Samples were taken at the seawater inlet, at the EGCS tower outlet, and at the overboard discharge outlet.

7 The parameters tested for each sample are listed in table 1 below.

| PAHs | Metals* | Other parameters |
|---|---|---|
| 1-Methylnaphthalene | Aluminum (Al) | C10 – C40 Hydrocarbons |
| 2-Methylnaphthalene | Cadmium (Cd) | Chloride |
| Acenaphthene | Chromium (Cr) | Total Dissolved Solids |
| Acenaphthylene | Copper (Cu) | Total Suspended Solids |
| Benzo(a)anthracene | Iron (Fe) | Ammonia as N |
| Benzo(a)pyrene | Lead (Pb) | Total Phosphate as PO4 |
| Benzo(b)fluoranthene | Nickel (Ni) | Total Phosphorus as P |
| Benzo(g,h,i)perylene | Thallium (Tl) | Total Organic Carbon |
| Benzo(k)fluoranthene | Vanadium (V) | Total Kjeldahl Nitrogen |
| Chrysene | Zinc (Zn) | Chromium (VI) |
| Dibenz(a,h)anthracene | Arsenic (As) | pH |
| Fluoranthene | Selenium (Se) | Nitrate + Nitrate as N |
| Fluorene | Mercury (Hg) | Biological oxygen demand (BOD) |
| Indeno(1,2,3-cd)pyrene | | Chemical oxygen demand (COD) |
| Naphthalene | | Organic Nitrogen |
| Phenanthrene | | Total Nitrogen |
| Pyrene | | Ammonium |
| | | Diesel Range Organics (DRO) |

* Analysis was for both Total and Dissolved portion

**Table 1**

[1] http://media.corporate-ir.net/media_files/IROL/14/140690/Carnival-DNVGL_Washwater_Analysis_2018.pdf

8 The ISO 17025-certified laboratory analysis utilized in the study established analytical methods and procedures for measurement techniques, standardization, hold times, and calibration. Samples were analysed for net post-EGCS concentration, i.e. concentration at the EGCS Tower outlet (immediately following scrubbing and prior to mixing or dilution), less the concentrations detected in the incoming seawater. The intent in using the net concentration was to correct for the amount already present in background concentrations in the incoming seawater and to accurately show how the EGCS contributes to a change in concentration of each parameter.

9 The objective of the assessment was to evaluate average washwater concentrations. Identification of correlations between parameter concentrations and fuel type or quality, fuel consumption, dilution rates, flow rates and engine loads were outside the scope of the assessment. A separate, but related, accumulation study is underway using the MAMPEC model[2]; CLIA looks forward to informing the Committee of the results when available.

**Observations from the lab results**

10 A significant number of samples for each parameter were "non-detects", indicating that an analyte was not present, or present at a concentration below the lab detection limits. For results reported as non-detects, it was conservatively assumed, consistent with US EPA statistical analysis guidance, that the sample was half of the detection limit.

11 Based on standard statistical analysis consistent with the United States Geological Survey's Statistical Methods in Water Resources, outliers more than three standard deviations from the mean were excluded. The percentage of samples excluded varies between 0.4% (1 sample) and 3.2% (9 samples), out of 281.

12 Distribution of "detects," "non-detects" and statistical outliers for select inlet and post-EGCS samples are shown in tables 2 and 3 below, respectively. The inlet samples (table 2) consistently showed background concentrations of metals present in the incoming seawater and a low number of detects for PAH. The post-EGCS samples (table 3) show an increase in detectable levels of PAH and some metals.

[2] The MAMPEC model is recognized and used by regulatory authorities in the EU, US and by the IMO for ballast water discharges. https://www.deltares.nl/en/software/mampec/

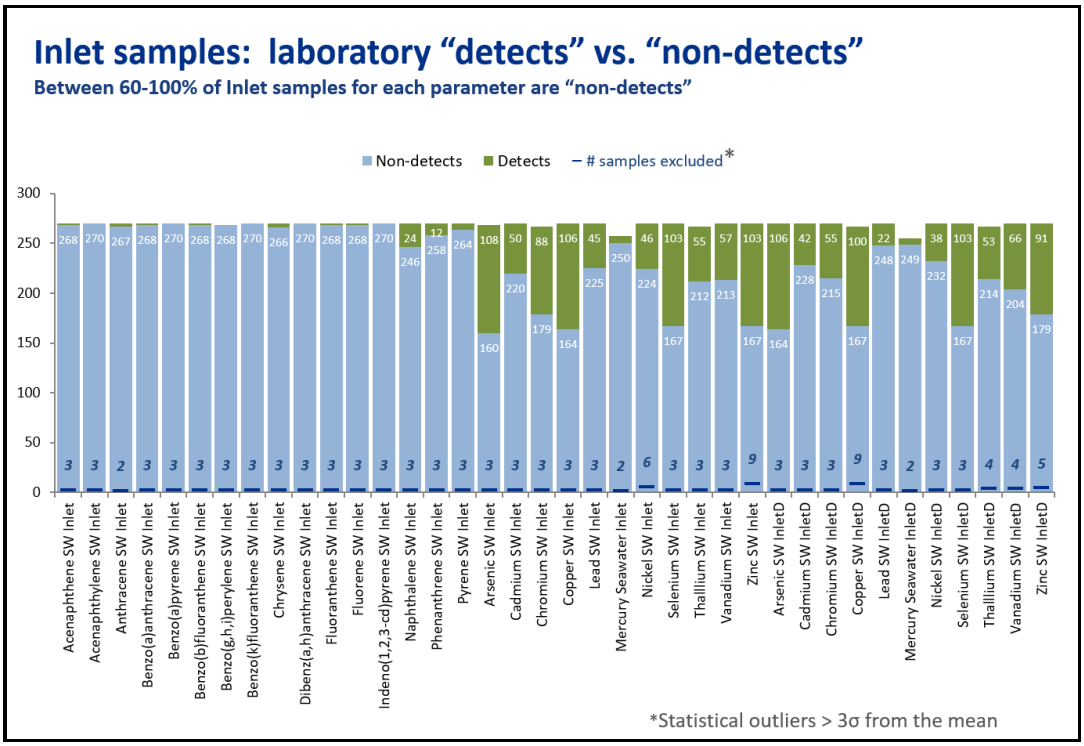


**Table 2**

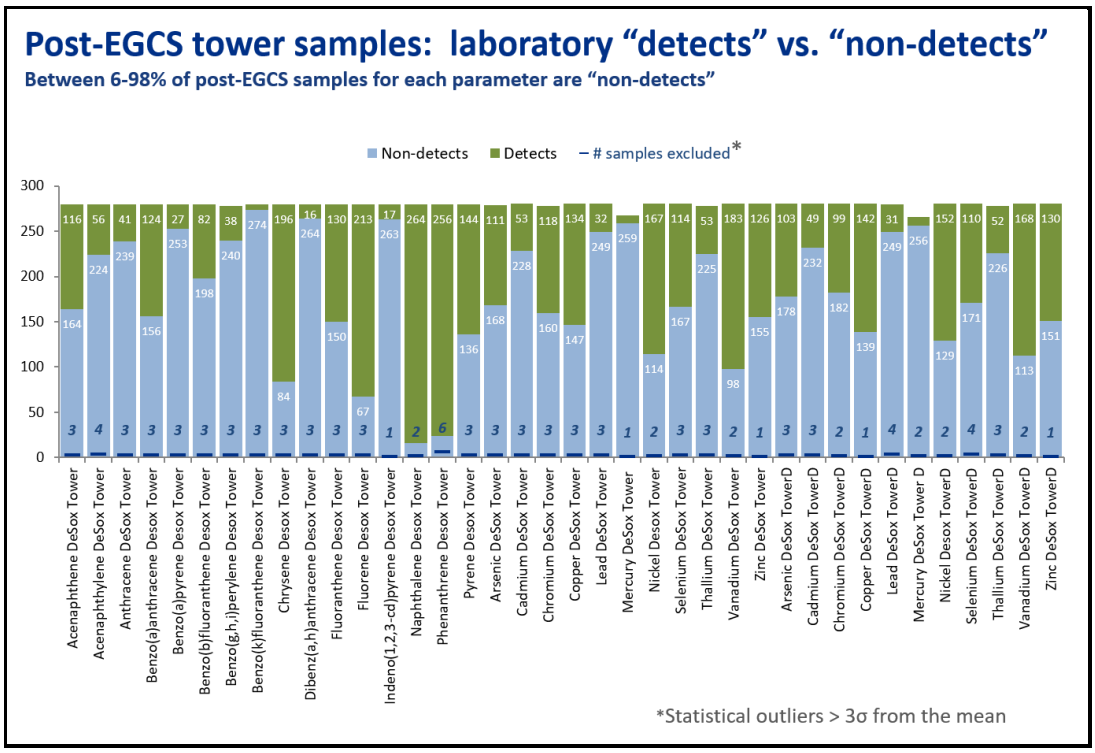


**Table 3**

13 As an example, post-EGCS sample distributions for Nickel are shown in table 4 below. The distribution indicates the number of samples above the detection limit, including outliers; the number and percentage of samples considered outliers; and the average detection value for the parameter tested, with and without outliers.

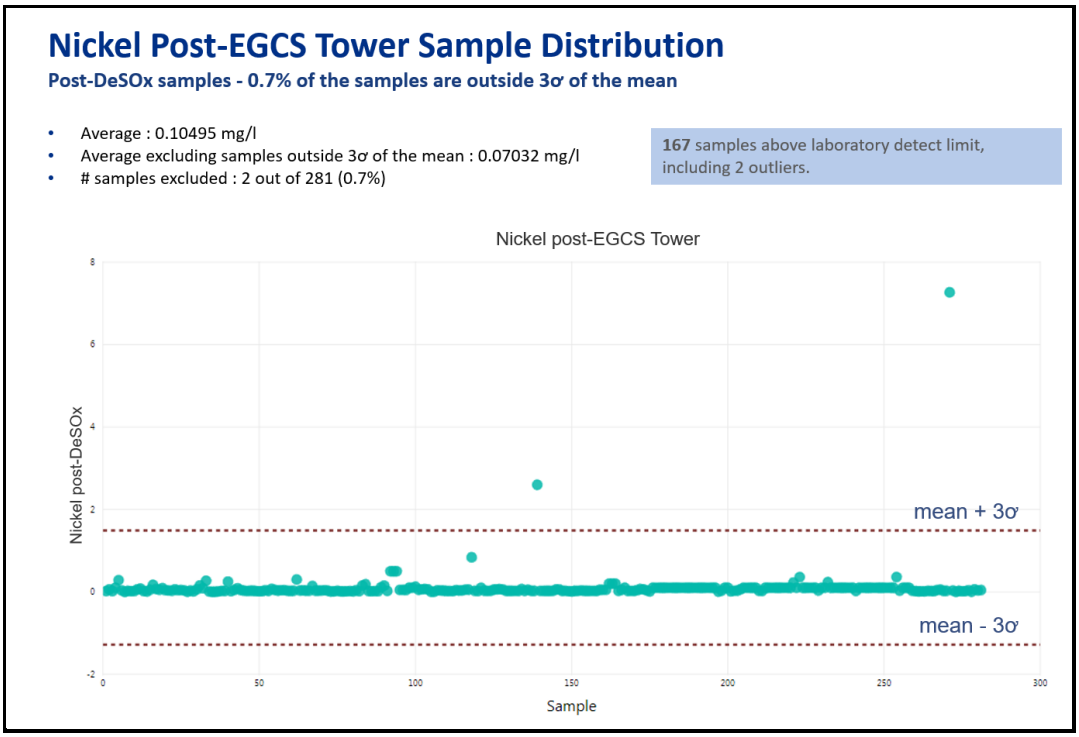


**Table 4**

## Average net post-EGCS analysis

14 Analysis of PAH and Nitrate concentrations demonstrate that average PAH and Nitrate levels are well below IMO washwater discharge criteria, even where the strictest PAH and Nitrate limits are used, rather than normalizing for operating conditions.

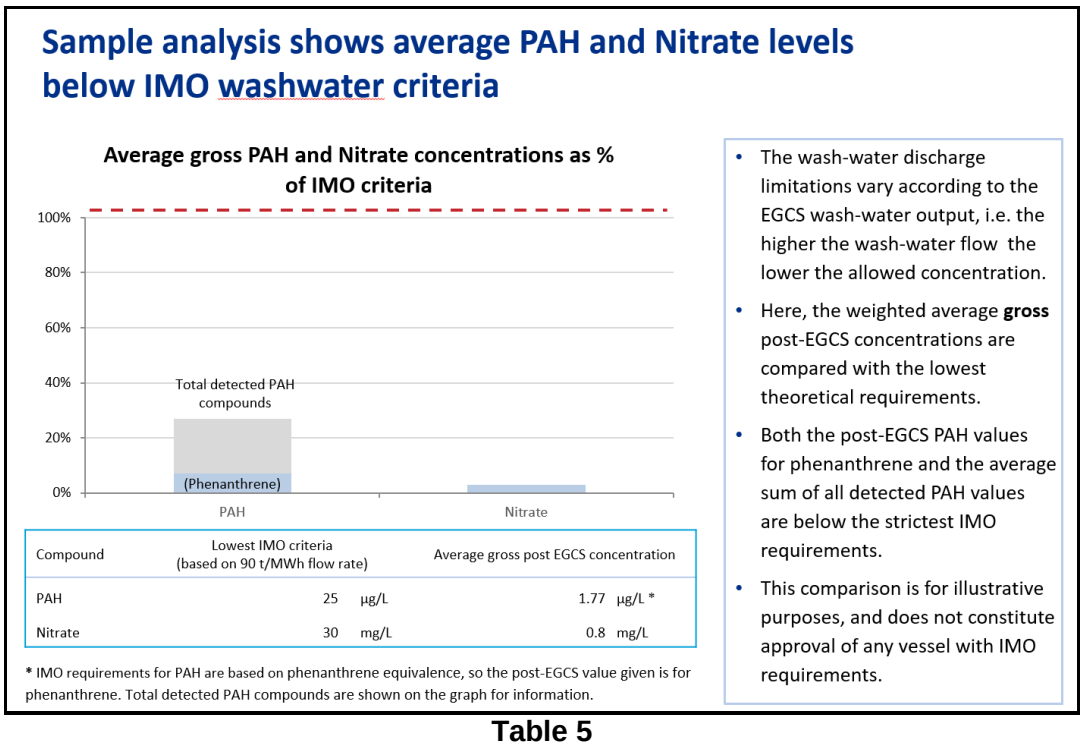


**Table 5**

15 The net post-EGCS sample analysis results were evaluated against the following:

.1 German Waste Water Ordinance (Article 2 of 6th Ordinance for Amendment of Waste Water Ordinance, Federal Water Act). See table 6 below;

.2 EU Waste Gas Cleaning Water Standards (Annex VI, Part 5 of Directive 2010/75/EU, Industrial Emissions Directive). See table 7 below;

.3 EU Surface Water Standards (Annex II, Part A, Directive 2013/39/EU, amending Water Framework Directive 2000/60/EU). See table 8 below: and

.4 WHO Drinking Water Guidelines (Guidelines for drinking-water quality, Fourth Edition, incorporating the 1st Addendum). See table 9 below.

16 These water standards were chosen because they provide relatable criteria for a number of the parameters of interest. These comparisons do not constitute the basis for determining if washwater is compliant to the selected standards.

## German Waste Water Ordinance, net post-EGCS analysis

### Difference between the post-EGCS and Inlet averages

- This comparison uses the German Waste Water Ordinance (Article 2 of 6th Ordinance for Amendment of Waste Water Ordinance, Federal Water Act), waste water limitations from biological waste treatment.
- This ordinance was chosen as a point source discharge standard and due to the total metal criteria being well aligned with the tested parameters.
- The waste treatment criteria did not include vanadium limits, so this criteria limit is for steam generation (from the same ordinance), in order for vanadium to be included as a metal of interest.
- The standard contains no PAH criteria.

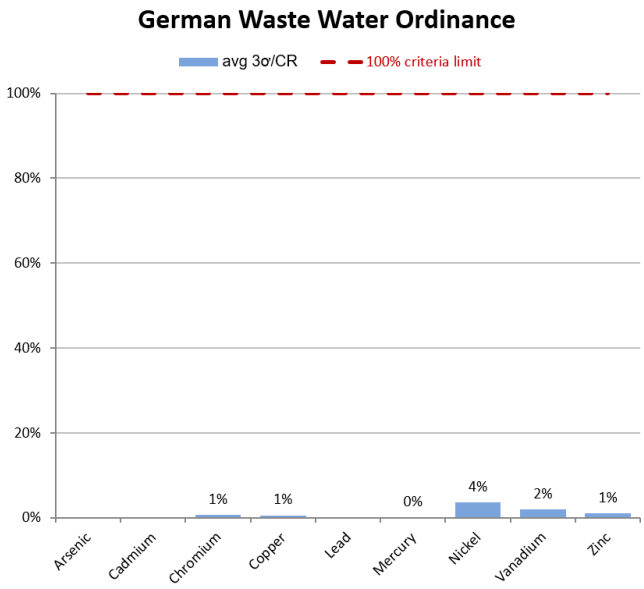


**Table 6**

## EU Industrial Emissions Directive, net post-EGCS analysis

### Difference between the post-EGCS and Inlet averages

- The Waste Gas Cleaning Water Standards (part of EU Industrial Emissions Directive 2010/75/EU) refer to emission limit values applied to point source discharge from waste water from the cleaning of waste gases from incineration or co-incineration plants.
- The standard includes limits for trace metal parameters similar to the German Wastewater Ordinance. The criteria are generally somewhat stricter (there is no Vanadium criterion).
- The standard contains no PAH criteria.

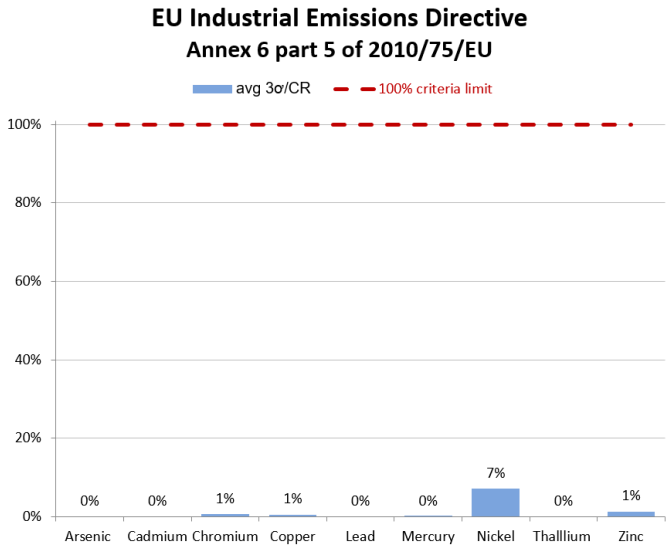


**Table 7**

## EU Surface Water Standards, net post-EGCS analysis

### Difference between the post-EGCS and Inlet averages

- The EU Surface Water Standards (as amended by Directive 2013/39/EU) , part of the EU Water Framework Directive, refer to maximum allowed concentration* in inland surface waters.
- Surface water criteria imply that the concentrations shall not reach the maximum concentrations. This comparison does not account for any potential accumulation effect on ambient water.
- While as a water quality standard it is not intended for application to point source discharges such as EGCS washwater, it provides a useful point of reference for PAH concentrations.
- The metal concentration criteria are for dissolved (D) metals.

* Maximum allowable concentration is the maximum concentration a pollutant is recommended to have at any given time in the water body in question.

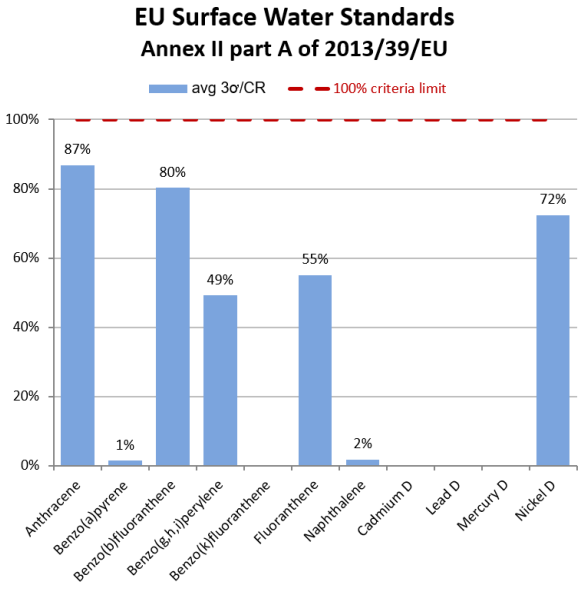


**Table 8**

## WHO Drinking Water Guidelines, net post-EGCS analysis

**Difference between the post-EGCS and Inlet averages**

- This comparison is for general interest only. These Guidelines are used as the basis for regulation and standard setting world-wide.
- The total metal criteria are stricter than for point source discharge standards (versus EU Surface Water Standards which use dissolved metal criteria).
- Value for **nitrate** is based on detected values only.

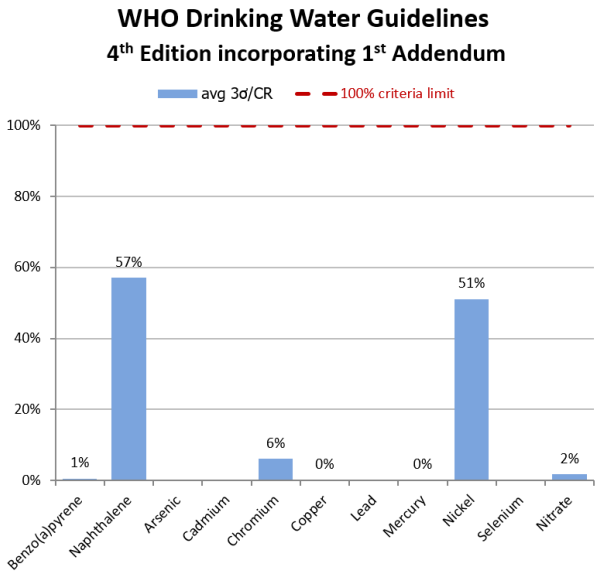


**Table 9**

## Action requested of the Committee

17 The Committee is invited to take note of the information provided in this document.